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RECOMMENDATIONS FOR IMPROVEMENT OF AN/TSQ-47 RELATIVE TO SYSTEM INTEGRATION TESTS

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FOREWORD

The entire effort described in this report was performed by the contractor at the USAF facility located at Fort Dawes, Winthrop, Massachusetts. Technical guidance was performed by Mr. Benjamin F. Greene, Jr., Chief, Technical Support Division, 482L Systems Program Office, ESD.

RECOMMENDATIONS FOR IMPROVEMENT OF
AN/TSQ-47 RELATIVE TO SYSTEM
INTEGRATION TESTS

ABSTRACT

This report concerns the AN/TSQ-47 System Integration in accordance with Contract AF 19(604)-8020, item 8. This report provides specific recommendations concerning improvements to the AN/TSQ-47 System, in many areas, as well as to the support subsystems of the EMS concept.

REVIEW AND APPROVAL

This technical documentary report has been reviewed and is approved.

B. F. Greene, Jr.

B. F. GREENE, Jr.
Technical Contract Monitor

KEY WORD LIST

1. COMMUNICATION SYSTEMS
2. COMMUNICATION EQUIPMENT
3. NAVIGATIONAL AIDS
4. AIR TRAFFIC CONTROL SYSTEMS
5. PORTABLE
6. PERFORMANCE TESTS
7. ANALYSIS
8. SHELTERS
9. EXPERIMENTAL DATA

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SECTION 1

INTRODUCTION

This is the final report concerning Task 8 of Contract AF19(604)-8020. This report concerns the system integration of the AN/TSQ-47 System.

After the fabrication of the AN/TSQ-47 System, and testing of the unit, many recommendations could be made to increase the capability, or effectiveness, decrease the overall weight and support required. At the present time the entire test phase is not complete, however, many recommendations can be made at this time based on the testing that has been accomplished.

This report defines many areas of improvement which will increase the operating capability of the system. In the area of the IFF/SIF System, increased reliability and extended range out to 200 n. miles will provide the AN/TSQ-47 System with a complete back-up search system while controlling military aircraft.

The addition of the hybrid circuit to the Air/Ground/Air communication adds increased capability to the system. The present AN/TSQ-47 communication system requires as much as 8 mc. separation while using the multicouplers to obtain proper isolation. By utilization of the hybrids, the transmitters can operate on the same frequency and obtain 30 db isolation. By frequency separation of 2 mc, the figure increases to 70 db. Many areas of improvement can be realized throughout the system. This report attempts to define the areas of improvement where: increased traffic handling capability, increased flexibility and increased mobility, by reduction in weight, is obtained.

SECTION 2

SUMMARY

This report is primarily concerned with recommendations for improvements of the AN/TSQ-47 Air Traffic Control and Communications System.

For reference, a description of the AN/TSQ-47 and associated major subsystems is included in Section 3 and the operational concept is discussed in Section 4. In addition, Section 5 discusses SIF/IFF compatibility with regard to requirements and recommendations contained in the U. S. National Standard for common system component characteristics approved by the International Civil Aviation Organization.

Improved communications control and audio distribution is recommended in Section 6 along with further recommendation that the communications control and indication features be standardized for the four shelters concerned with this function.

In Section 7, improvements of the landline subsystem are discussed. Included are recommendations for a simple method of automatic transfer to emergency DC power. Also recommended is dial-type interphone system for the AN/TSW-5 shelter.

Utilization of hybrid couplers to obtain additional isolation of VHF and UHF equipments on the same antenna is recommended in Section 8.

In Section 9, a method of adapting RACEP to enable control directly from a dial telephone is discussed. This should greatly improve the accessibility and utilization capability of RACEP.

Section 10 discusses improvements of the microwave subsystem. Provision of an additional microwave channel for the IFR-PAR microwave link is recommended for greater reliability. A method of

simplifying azimuth data transmission via cable for the IFR-Search microwave link is discussed. Recommendations for improvement of the microwave antenna mounts is also included.

Improvement of the AN/TVN-1 lighting system is discussed in Section 11. Change from an AC to a DC lighting system as recommended should result in a weight saving of approximately 2000 pounds. Miniature lights are recommended as an approach to further weight savings.

Section 12 recommends the replacement of the RT-211 IFF/SIF interrogator unit with a new and improved set designated as the AN/TPX-28.

Miscellaneous recommendations for improvement of the AN/TSQ-47 are listed in Section 13. This section includes recommendations for diesel generators for extended deployment periods, lean-to's for all shelters, extended range presentation of IFF/SIF on PPI's in the AN/TSW-5, and shelter improvements for operation with 463L loading system.

Section 14 contains conclusions and recommendations relative to the preceding sections of this report.

SECTION 3

HARDWARE DESCRIPTION OF AN/TSQ-47

In order to fully understand the recommendations presented in this report relative to the AN/TSQ-47, an essential prerequisite is a general knowledge of the hardware and the system concept. A general discussion of the hardware is contained in this section and a discussion of the system concept is discussed in the following section.

1. The AN/TSW-5 Sub-System

The AN/TSW-5 Sub-System (RAPCON), as shown in Figure 1 contains the required air-ground-air communications necessary to maintain positive contact with aircraft within the terminal control area. The system contains seven UHF transmitter receivers, each with the capacity of 1750 frequencies in the UHF band of 225.0 mc to 399.9 mc. Two UHF antennas are provided, and up to four transceivers are connected to a common antenna by means of one of two UHF multi-couplers. The antenna couplers have the advantage of a selective filter to give frequency isolation between transmitters and receivers operating at closely speaced frequencies.

The communications system also contains six VHF transmitters and receivers operating in the VHF frequency band. The transmitter has a frequency band of 116 mc to 149.95 mc; the receiver has a frequency band of 108.0 mc to 151.95 mc. The receivers may be manually switched to any one of 880 frequencies. Selection is manual, but tuning is automatic. The transmitters may be tuned to any one of 680 different frequencies in the same manner. The VHF transmitters and receivers are also provided with antenna couplers containing selecting filters to provide isolation between units coupled to a common antenna.

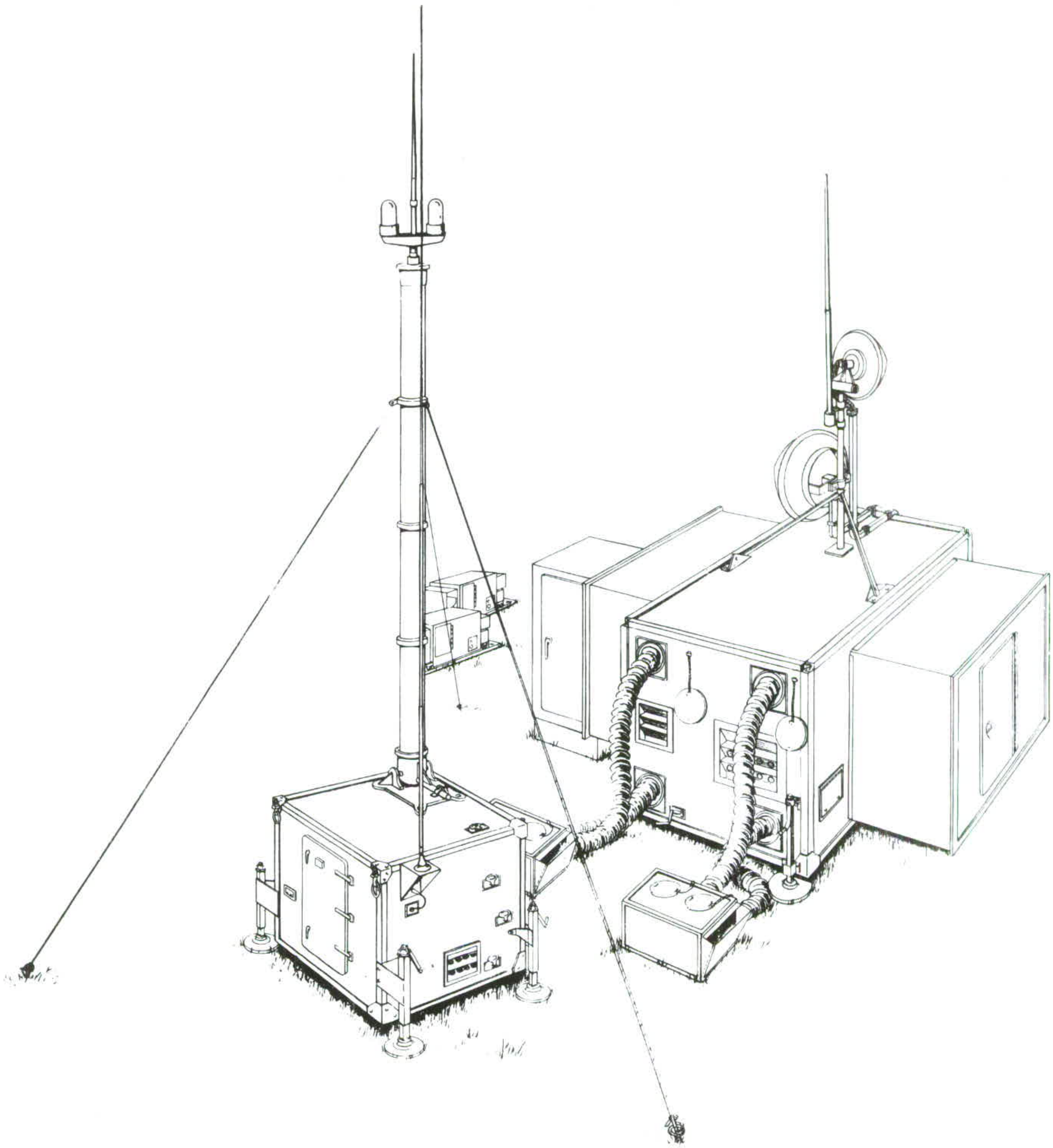


FIGURE 1: AN/TSW-5 Shelter

A single HF communication set in the system is capable of simplex voice on single-sideband. The unit will cover ground point-to-point requirements on the 2 mc to 30 mc frequency band as well as HF air-ground-air requirements.

In addition to air-ground-air communications, the RAPCON contains three independent VHF transceivers providing all controllers with a selective digitized voice interfacility communications system. The controllers have the capability to talking to any RACEP equipped shelter in the AN/TSQ-47 system as well as other stations, such as base operations, the maintenance van, the squadron command office, etc. A back-up interfacility landline communications system is also provided. This telephone landline system, containing three end pieces and junction boxes coupled to three independent landlines, permits three controllers the access to a "hot line" fed to a predetermined location. The telephone system also provides a tie into a central dial exchange if this equipment is available at the operational site. Two microwave terminals are available in the RAPCON for the acquisition and transmission of data from the AN/TSQ-47 remote radar systems. A microwave remoting system eliminates problems associated with a remoting cable. However, both the search radar and PAR have provision for back-up remoting cable which may be used with limited flexibility if the primary microwave system fails.

The IFR control shelter in the RAPCON has many features providing operational flexibility of the search and PAR radars which are selectable at the individual controller's request. Such features as anti-clutter circuits, friendly interference eliminators and anti-jamming circuits are selectable by the controller. A microwave remoting system junction is located in the IFR shelter near the coordinator's position

to provide this feature. In case of the search radar, the operator can adjust the gain of the radar receiver, the MTI receiver, the IFF receiver sensitivity time control, by means of remote control. He may select such features as fast time constant, sensitivity time control, pulse width discrimination, or circular polarization. In the case of the PAR system, the operator may adjust the gain of the AZ receiver and the EL receiver. He also has positive control of the antenna servo system. He may select such circuits, via remote control, as sensitivity time control and fast time constant. He also has required provisions for resetting the high voltage.

The search display system is comprised of four identical 22-inch plan position indicators. Three of the units are arranged as vertical displays, and the fourth as a horizontal display. All the units are completely interchangeable and include the automatic symbol generator and tracking system. This system will supply up to 16 simultaneous electronic symbols to the display. The symbols will automatically track an assigend target until released by the controller. The symbol display will be present on each PPI unit. The automatic generator and tracker unit is backed up with small manual symbols if the need occurs. A projector is located above the 4-position horizontal display to provide a projected overlay which contains all the necessary deployment information, such as location of TACAN, terrain, search radar location, and airfield location. A detachable map projector is attached to the feeder controller position to provide the same function.

Two PAR AZ-EL beta scan indicators are located in the IFR shelter to receive the PAR signals and provide remote operation of the PAR system. Two operators, each with an indicator supplied from a common PAR system, can exchange control of the PAR as the need

presents itself. Two controllers working in coordination will significantly increase landing acceptance rates of the system over that possible with only one controller. The two AZ-EL indicators are mechanically and electrically interchangeable with each other as well as with the one located in the PAR shelter.

All nine controllers have the capability of selecting any of the UHF units, the VHF units, the HF unit, or the wireless interfacility communications. The three vertical PPI controllers have the provisions of three independent SIF/IFF decoder/control units to single out their own target responsibility and not display any other IFF marks. Three controllers, the pick-up, coordinator, and feeder, have speaker positions to monitor any receiver in the communications complement.

2. <u>The AN/TSW-6 Sub-System</u>

The AN/TSW-6 Sub-System, as shown in Figure 2, consists of a VFR tower containing, UHF, VHF, and HF air-ground-air communications facilities. The various transceivers are integrated through a communication switching configuration installed in three operator positions. Included in the shelter are navigation aids comprising a UHF direction finder receiver with a remote indicator, and a remote control unit monitor for the AN/TRN-17 van. It also is provided with intershelter radio communications in addition to limited landline facilities. The Tower facilities provide positive control of military aircraft near or on an airfield under VFR during conditions of high traffic density. The control capability is by UHF, VHF, and HF communications.

The Tower has accommodations for three operator positions with primary responsibilities delegated as follows:

Local position - Control of aircraft arriving and departing from the local airstrip

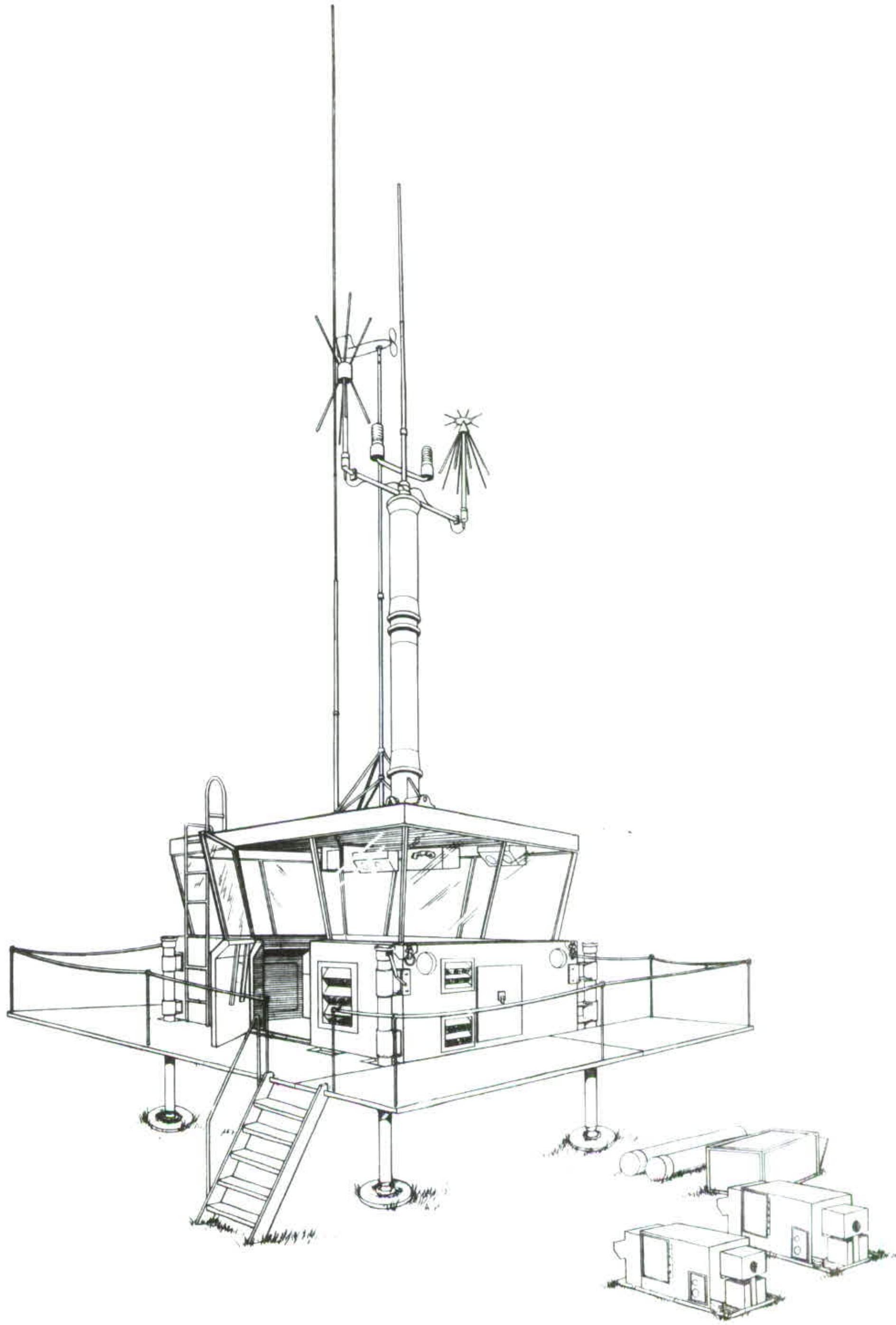


FIGURE 2: AN/TSW-6 Shelter

Data position - Updating of flight strip, VFR-IFR coordination and alternate duty of local or ground operators.

Ground position - Control of departure clearances and ground traffic.

When operating in conjunction with the PAR and RAPCON vans, the Tower accepts hand-over of aircraft from IFR facility, at which time the aircraft passes from IFR to VFR status.

The Tower provides very limited capability to perform procedural IFR approach control during conditions of low traffic density. To perform these functions, a UHF direction finder is provided, used in conjunction with the ground TACAN Sub-System.

The DF facilities provide the controllers with an immediate line of position reference of aircraft traffic, thereby providing the capability to direct traffic to the operating location. When other navigations facilities are inoperative, the DF equipment provides a marginal capability to the controllers to exercise aircraft instrument let-downs. An HF radio capability is provided to serve as a temporary inter-site means of relaying flight data, estimates, status reports, weather, operational messages, and acquiring operational time checks. The A/G/A communications contained in the AN/TSW-6, consist of 5 UHF transmitter/Receivers operating in the 225.0 to 399.9 mc range, 4 VHF transmitter/Receivers operating in the 108.0 to 151.95 mc range, and HF SSB, voice transmitter/receiver operating in the 2 to 30 mc range.

3. The AN/TPS-35 Sub-System

The AN/TPS-35, as shown in Figure 3, is a lightweight, air transportable, sheltered search radar sub-system used as the Air Traffic Control device of the AN/TSQ-47 system. The AN/TPS-35 contains a high performance Search Radar Group, a microwave

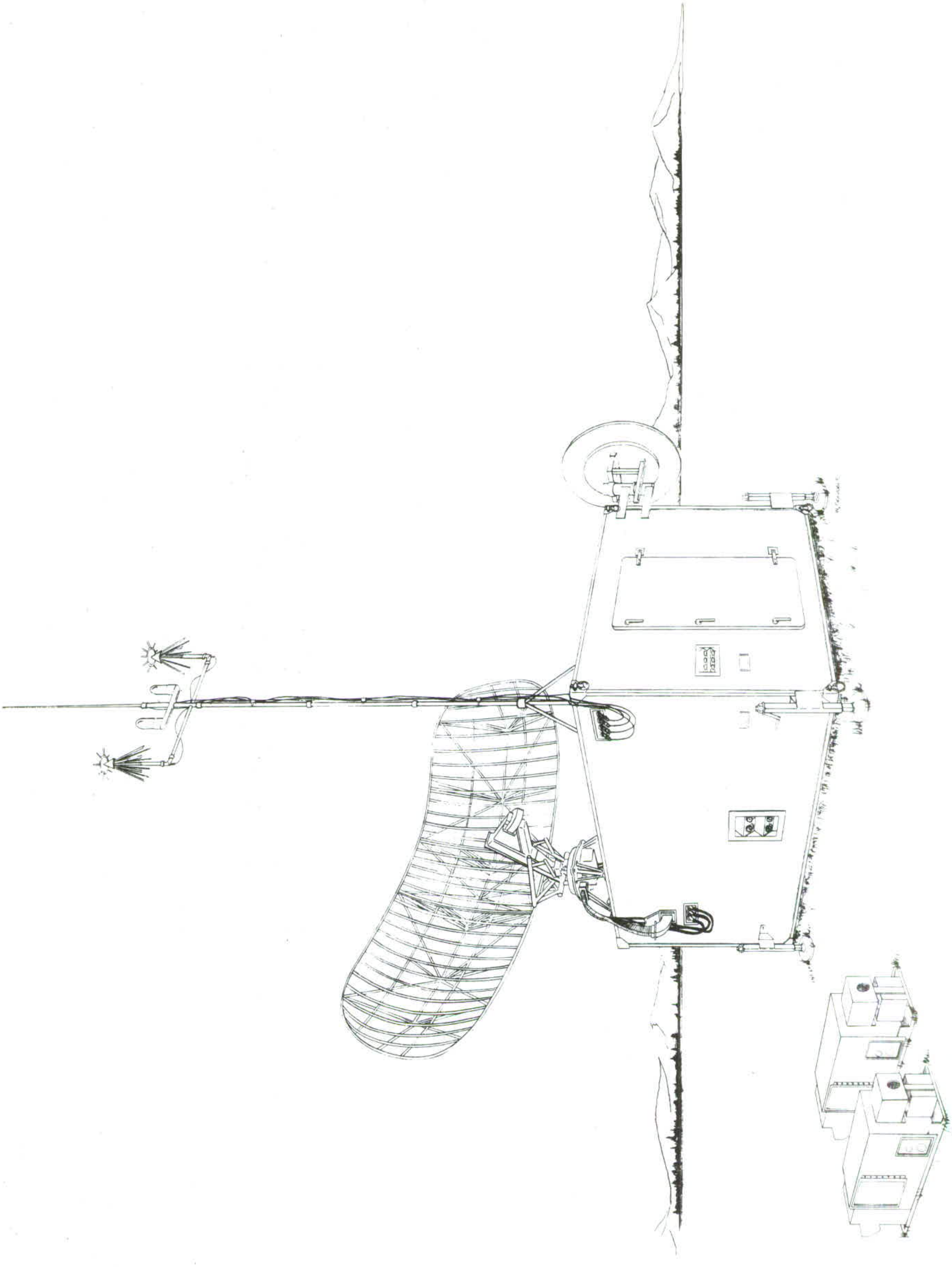


FIGURE 3: AN/TPS-35 Shelter

remoting group, a UHF air-ground-air communications group, an interfacility communications group, an IFF/SIF interrogator group, and the necessary power devices, cooling units, etc.

The function of the AN/TPS-35 is to provide two dimensional, aircraft present position data on small cross-section aircraft at ranges up to 80 nautical miles as the normal operating mode, as well as provisions up to 275 nautical miles if desired. This is accomplished in the presence of weather, clutter, friendly, and unfriendly interference. The AN/TPS-35 provides interrogation pulses to properly equipped aircraft to enable the identification of aircraft under control to be accomplished. The AN/TPS-35 supplies the aircraft position information to the RAPCON unit up to 15 miles away. The remote control and data signals are transmitted and received over this path by utilizing an electronic microwave remoting system. All the necessary signals and controls required to provide this flexibility are carried by this remoting link.

The AN/TPS-35 Radar group contains a parametric amplifier to increase system performance; a frequency modulated, moving target indicator unit to provide clutter free presentations, an improved sensitivity time control unit to decrease clutter out to 80 nautical miles, a pulse width discrimination unit, a fast time constant circuit, a video sweep integrator unit, a P.R.F. stagger circuit to identify any "second time around" targets, circular polarization system, and a complete ECCM System to prevent unfriendly interference. The circuits and units are necessary to provide positive aircraft information with the least amount of clutter possible. Some important parameters of the surveillance radar are as follows:

Frequency	1250-1350 mc
Antenna gain	27 db

Antenna Horizontal Beamwidth	3.7°
Antenna Vertical Beam Shape	CSC^2 to 42°
Antenna Horizontal Side Lobes	25 db down
Radiated Polarization	Horizontal or circular
R.F. Power Output, Peak	1 megawatt
PRF/Pulse width	800 PPS/1.4 microsecond or 267 PPS/4.2 microsecond
System Noise Figure	3.5 db maximum (with paramp) 9.0 maximum with conventional
Receiver bandwidth	1.0 mc Short range mode 330 Kc Long range mode
MTI performance	30 db SCV
Antenna Scan rate	0 to 15 RPM

Shelter Intercommunications Group (RACEP)

Frequency	VHF band
Maximum Callable Stations	700
Number Preselected Pushbutton Stations	6
Range	to 15 miles
Modulation Type	PPM

UHF Communications Group

Frequency	225 to 399.9 mc
Number Preselected Frequencies	1750
Transmitter Power Output	20 watts
Receiver Sensitivity	5 microvolts

IFF/SIF

Transmitter Frequency	1080-1130 mc
Receiver Frequency	990-1040 mc
Transmitter Power	1.5 KW peak

Receiver Sensitivity	80 db below 1 volt
Antenna Gain	27 db

4. The AN/TPN-14 Sub-System

The AN/TPN-14 precision approach radar sub-system, as shown in Figure 4, provides precision azimuth range, and elevation radar information to the AN/TSQ-47 system. The AN/TPN-14 radar set can function to permit aircraft approaches from either end of the runway, The AN/TPN-14 can utilize minimum tracking ranges, and has the capability of shifting between pre-set approach courses and glide slopes. The AN/TPN-14 contains the necessary power supplies, modulator, transmitter, receivers, indicator group, and antenna group to generate the precision video necessary for the final controllers to "TALK" down the aircraft under extreme IFR conditions. To increase the flexibility of the system, a microwave remoting equipment is provided as part of the AN/TPN-14 sub-system for the purpose of remoting the video, and control circuits to the main indicator group located in the AN/TSW-5 RAPCON sub-system. The AN/TPN-14 also contains inter-facility communications, air-ground-air communications, and some necessary friendly interference anticlutter circuits.

Some of the significant features of the Precision Approach Radar Set include:

(1) Selectable linear or circular polarization for both azimuth and elevation.

(2) Selectable pulse width for maximum sensitivity or resolution.

(3) Monopulse operation in the elevation pattern to obtain increased angular resolution.

Monopulse operation in the height finding portion of the system effectively narrows the elevation antenna beamwidth by a significant

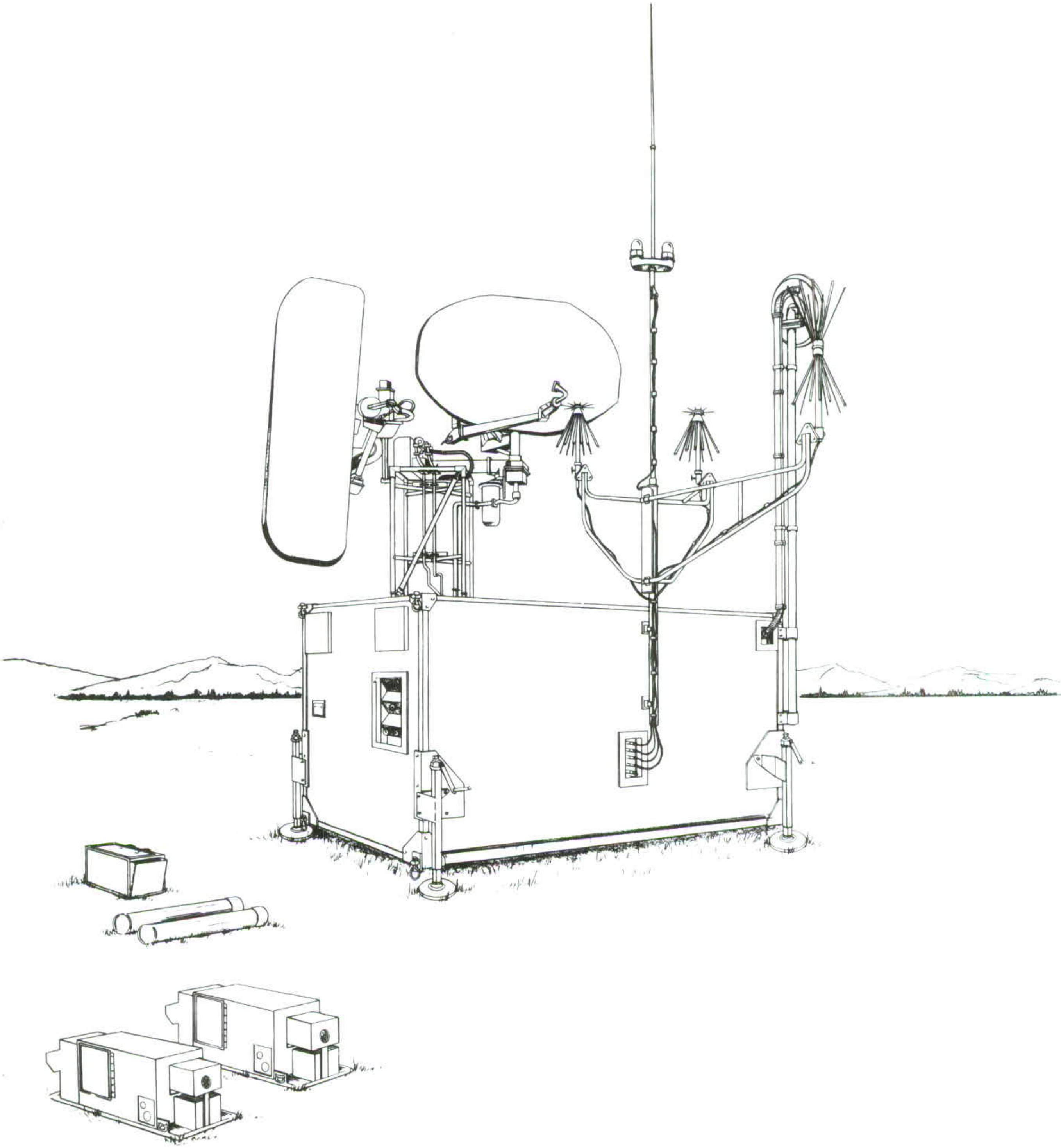


FIGURE 4: AN/TPN-14 Shelter

factor, thus providing an improved control of aircraft and increasing discrimination between targets and clutter. Circular polarization is selectable on both antennas to reduce the amount of clutter return and attenuation due to rainfall effects.

Relevant parameters of the AN/TPN-14 are as follows:

Radar Group

Frequency	X band (9000-9600 MC)
Peak Power	200 KW
Pulse width	0.2 and 0.8 microseconds
Pulse Repetition Frequency	1200 PPS
Minimum Discernible Signal	-102 dbm for 0.8 microseconds pulse

Antenna

Elevation	
Beamwidth (vertical)	1.1°
Beamwidth (horizontal)	3.5°
Gain	38 db
Polarization	Vertical or Circular
Scan Coverage	-1° to 10° and -1° to 35°
Azimuth	
Beamwidth (horizontal)	1.3°
Beamwidth (vertical)	3.5° CSC^2 to 30°
Gain	38 db
Polarization	Horizontal or Circular
Scan Coverage	30° to 60°
Precision Approach	
Display	Beta AZ and EL Display
Ranges	Logarithmic -5 and 10 miles Linear - 20 miles

The AN/TPN-14 has the capability, with one operator position, and the necessary air-ground-air communications, to function as a back-up operational unit to the RAPCON when and if required. The air-ground-air communications consists of UHF, VHF, with the necessary interfacility RACEP unit.

5. The AN/TRN-17 Sub-System

The AN/TRN-17 Sub-System, as shown in Figure 5, includes both Government furnished and contractor furnished equipment. The sub-system serves as the primary navigational aid for the AN/TSQ-47 system. The sub-system is a transportable, ground-based, equipment for a polar coordinate navigation system. It provides, to TACAN equipped vehicles that are within line-of-sight of the radiating entity, the identity, range and relative bearing of the sub-system.

The active element of the sub-system is the Beacon-Transponder. The transmitter unit generates a constant amplitude train of pulses that include random noise pulses to maintain a constant duty cycle, regulated pulses for station identification, coded pulse burst for azimuth reference, and delayed responses to distant interrogations. The antenna imposes both coarse and fine amplitude modulation on the transmitter output. The azimuth of the vehicle is determined by measuring the phase relations at the vehicle between these modulations and the azimuth reference bursts.

The control element of the sub-system includes the Remote Control Panel, located in the AN/TSW-6 shelter.

The function of the control element is to monitor, and provide a mechanism for the insertion of remote manual control inputs, to the Beacon-Transponder.

The AN/TRN-17 sub-system contains a complete back-up

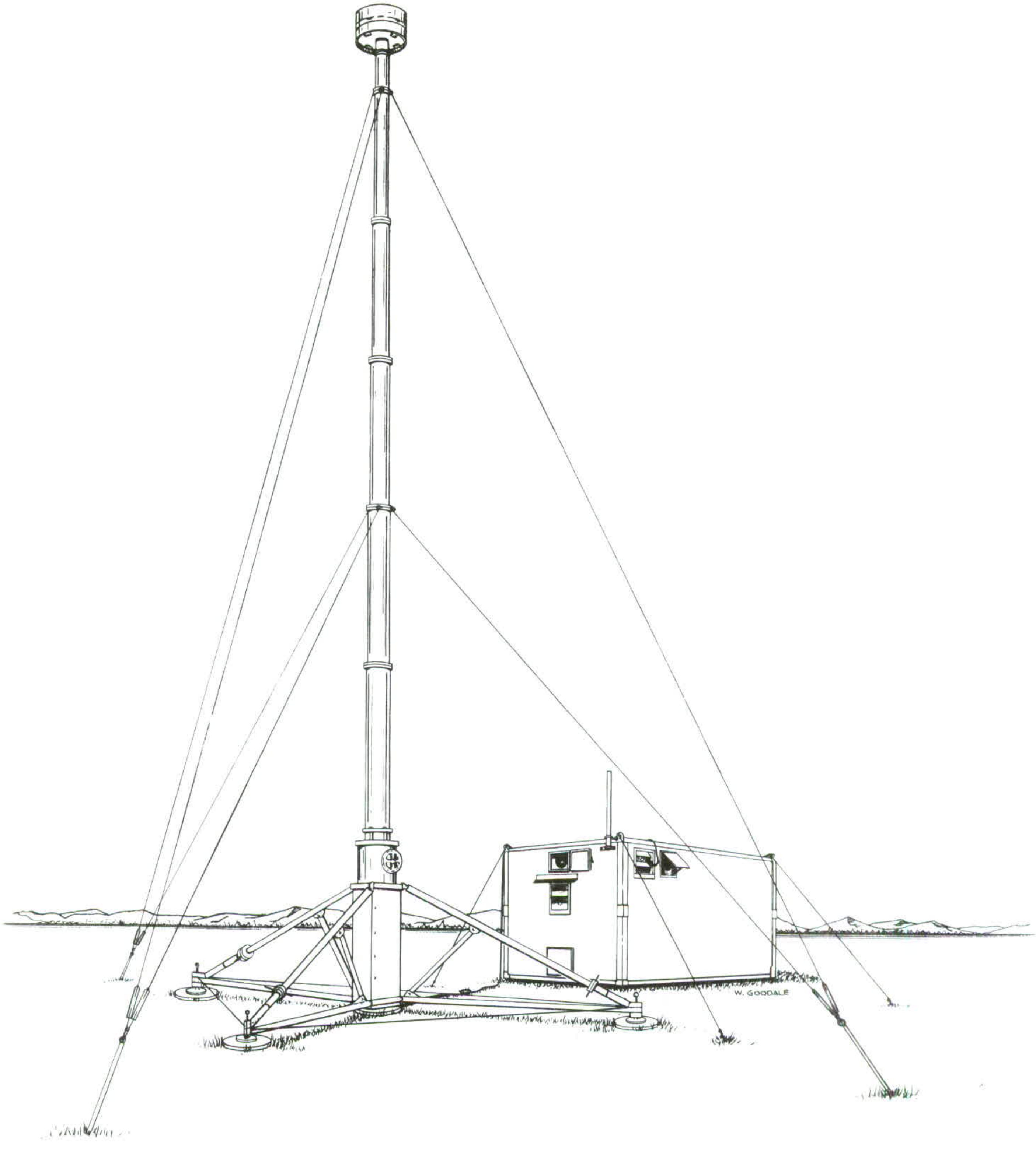


FIGURE 5: AN/TRN-17 Shelter

channel operating on the stand-by mode to be used if problems occur to the operational channel. However, the primary power, and antenna system are common to the two channels.

6. The AN/TSC-23 Sub-System

The AN/TSC-23 Sub-System, as shown in Figure 6, provides a long range, point to point communication capability in the high frequency range of 2 to 30 megacycles. It is linked to other components of the AN/TSQ-47 system over 15 nautical-mile communications paths by a wireless intercomm system operating in the VHF band. A capability for terminating local or long distance telephone circuits is also provided.

The electronic equipment is housed in a modified S-141 type shelter. Three HF communication RF channels are provided: each of two HF sets operates through antenna coupling equipment into log-periodic antennas designed to operate over the 4-mc to 30-mc range. Filter equipment at the HF receiver input permits the coupling of both the receiver and transmitter to a common log-periodic antenna with a proper separation of receiver and transmitter frequencies. The third HF RF system operates into two omni-directional antennas, one for transmission, and the other for reception. This unit operates in the 2 to 30 mc range.

The HF transmitters provide 1-kilowatt, single-sideband output with automatic tuning of both receiver and transmitter to preset frequencies. Manual selection of frequencies is possible in 100-cycle increments. Each of the three RF channels provides four 3-kc subchannels with two subchannels multiplexed in the upper sideband and two multiplexed in the lower sideband. This configuration provides a simultaneous full-duplex capability of twelve channels.

All HF audio circuits are brought to a cordless switchboard,

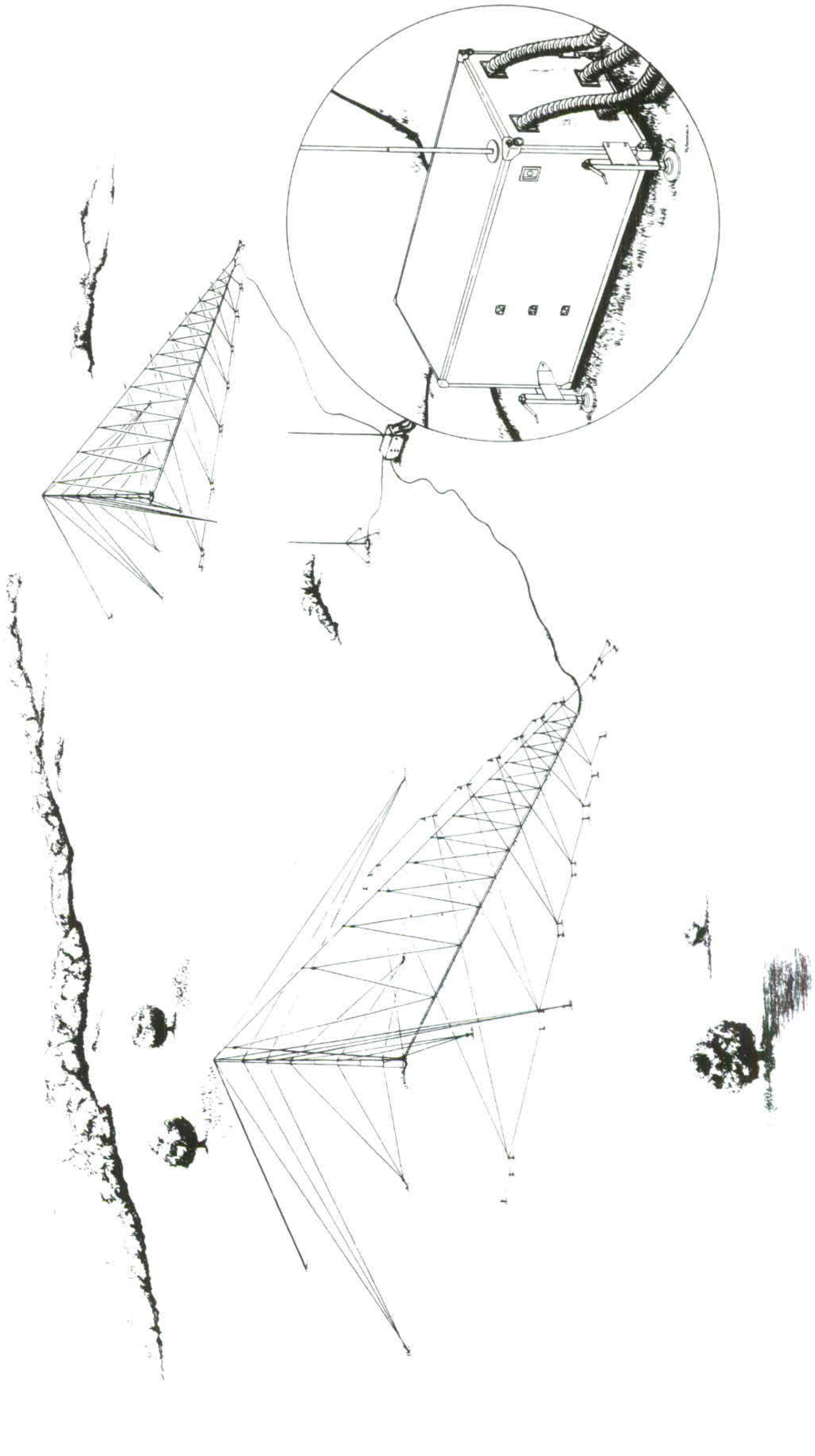


FIGURE 6: AN/TSC-23 Shelter

In addition to the HF audio circuits, the cordless switchboard provides switching capability for four telephone trunks and multiplexed FSK teletypewriter busses. The cordless switchboard enables patching of telephone-to-radio, radio-to-radio, and telephone-to-telephone circuits. Operators of the AN/TSC-23 may monitor or operate as a third party on any patched circuit.

Complete operator positions are provided for full duplex operation of on-line cyrptographic equipment composed on GFE KW-26D cryptographic units and teletypewrite terminals. Two additional teletypewriter positions are used for clear text and supervisory operations. Teletypewriter service, telephone lines, and radio circuits may be monitored by the AN/TSC-23 supervisor-operator.

The communications central is designed to maintain decoupling of classified and unclassified messages by separating, shielding, and proper identification of these two types of circuits.

SECTION 4

AN/TSQ-47 SYSTEM CONCEPT

1. General

The AN/TSQ-47 Emergency Mission Support System was designed to support air operations from the ground regardless of the weather conditions. The system provides air traffic control and long range point to point communications, with additional subsystems such as, Auxiliary Field Lighting, Field Maintenance, Transporters, Loading Pallets and ramps, Satellite Airfield Systems, and Proficiency Training Units assigned for support.

The AN/TSQ-47 system was designed to function in the field, completely isolated from all other traffic control agencies. Considering the conditions under which the system must function, and the volume and variety of traffic it must handle, the general characteristics are easy to understand.

2. AN/TPS-35 Sub-System

The AN/TPS-35 Search Radar Sub-System makes it possible to detect and track aircraft at long range, and high altitude, night and day, regardless of the weather. The Search Radar pattern supplies Rho-theta information (range and bearing) for the 80 n. mile terminal area, up to 45, 000 feet altitude.

3. AN/TPN-14 Sub-System

The AN/TPN-14 Precision Approach Radar provides the necessary AZ-range, and height information to the final controller in order that he may provide the precise guidance to land aircraft, regardless of visibility. The AN/TPN-14 Sub-System is assigned to the runway

area and contains all electronic equipment necessary to remote the video and control signals to the indicator group located within the RAPCON subsystem. The AN/TPN-14, therefore, can be unattended during operation.

4. AN/TSW-5 Sub-System

The AN/TSW-5 Sub-System contains all the necessary display and communications equipment required to maintain air traffic control within an 80 n. mile terminal area. Search Radar information is received via microwave link from as far as 15 n. miles away from the AN/TPS-35 sub-system which supplies the necessary rho-theta video to four plan position indicators. Precision Approach video is received via micro-wave link from the AN/TPN-14 sub-system which supplies two AZ-EL indicator units. Each of nine controller positions contains the necessary audio and communications switching required to select any of 14 air/ground/air communications units, or three wireless interfacility VHF units, or three land-line units.

5. AN/TRN-17 Sub-System

The AN/TRN-17 ground TACAN sub-system supplies the aircraft with continuous bearing information, and range up to 200 n. miles when interrogated. This unit functions to provide the necessary navigation aid to supply initial guidance into the 80 n. mile terminal area.

6. AN/TSW-6 Sub-System

The AN/TSW-6 Sub-System Control Tower enables the control of surface traffice such as, aircraft on the taxi strip, motor trucks requiring access to the landing area, and aircraft awaiting take-off. The AN/TSW-6 contains all the necessary communications equipment required to perform its function.

7. AN/TSC-23 Sub-System

The AN/TSC-23 sub-system provides the long range communications for the AN/TSQ-47 system. Facilities include nine teletype equipments with provisions for FSK operation over radio, plus additional provisions for voice radio and morse keying. Landline telephone communications facilities are also provided. Two full duplex channels are secure when required. The sub-system employs three R.F. systems, each containing four 3-K.C. sub-channels. The total peak power output is rated at one KW over the frequency range of from 2 to 30 mc.

8. Support Equipment

All sub-systems contain air-conditioning, 400 cps portable power, and may be air lifted using the 463L loading system to practically any location in the world. Upon arrival at the deployed site, the entire system can be made operational in a few hours.

9. Operational Requirements

The AN/TSQ-47 system is designed to function as a self-contained air traffic control system under tactical conditions and to operate 23 out of 24 hours for a continuous period of 30 days.

Under the emergency mission support concept, the AN/TSQ-47 system may be deployed at an isolated air strip; and in a few hours, assume efficient control of many types of aircraft. High speed inbound as well as extensive departure to all points, and more often a mixed load, will be expected. In time of war, little or no advance notice will be given, no prior flight plans, or expected time of arrivals teletyped ahead, no prior warning of assemblies or routine departures or destinations.

The control of aircraft under these conditions is a unique problem concerning the military. However, to meet these air traffic control

problems, a unique operational concept has been devised for the AN/TSQ-47 system.

In essence, this concept calls for complete radar control of all air operations throughout the 80 n. mile terminal area regardless of weather conditions. The prime responsibility of control is assigned to the Radar Control Center (RAPCON) which includes the pick-up controller, two approach and two departure controllers. The pick-up controller is seated at a vertical PPI scope, and the four terminal controllers are placed around a horizontal PPI display. Also included are a feeder controller, two final approach controllers and a coordinator equipped to perform all approach and departure functions as required.

During typical operations, an aircraft navigates toward the stations using the assigned TACAN channel. When the aircraft penetrates the terminal area, it establishes radio contact. The pick-up controller positively identifies the aircraft by use of the ground SIF/IFF system, at which time he assignes an electronically-generated tracking symbol to the radar target. This symbol appears on all PPI units and will track the target automatically until released. The pick-up controller at this time records the aircraft call sign, the aircraft type, initial penetration altitude, and its track symbol on a track symbol data card. The track symbol card is handed off, together with the control responsibility, to the approach controller. The card is at this time displayed for immediate reference on the data board. Each slot of the board is identified with one of the sixteen track symbols available. Display of this vital correlation between track symbol and call sign of the aircraft is the primary, and virtually the only purpose served by the data board.

Certain information which is desirable for control purposes is projected optically such as grid maps, courseline extensions, and fan-

shape patterns which define the feeder controller's area of responsibility. Inner curves are based on standard-rate turns at landing speeds, outer curves allows time for fine-grain alignment of aircraft approaching the glide-slope gate. The fan-shape display appears on both the approach control and feeder control scopes.

The main idea governing approach and departure control in the AN/TSQ-47 system is the concept of "Control by Exception", which means that after initial control instructions are given to an aircraft, further control is applied only when it seems to be necessary, as an exception to the initial instructions; deviations to avoid imminent collision, or to correct heading errors.

Working from the penetration altitude reported by the pilot, the approach controller rapidly computes both a vector and a constant rate of descent which will bring the aircraft within the feeder control fan in the shortest period of time, and at the desired altitude in that area; in effect, a heading and descent profile. The aircraft is then cleared to perform the specified maneuver. Conceivably, the aircraft could perform the entire maneuver without further instructions from the controller. The need for further control action can be detected directly from the radar display. At no time, are two tracks permitted to continue an apparent collision heading. If target paths are not permitted to intersect, then it is immaterial what the aircraft's respective altitude may be. By deviating either aircraft momentarily from its intended path in the horizontal plane, the elevation component is not a factor in the problem. The problem of possible conflict in the vertical plane does not exist because no aircraft is permitted to approach another beyond safe limits in the horizontal plane. Exceptions are made only in the horizontal plane depicted by the plan position display. The descent profile continues

relatively unchanged. The AN/TSQ-47 system concept supplies smooth marshalling of aircraft, optimum in both time and space, to accomplish a high landing rate and to insure positive control with minimum lost motion. As the traffic load changes, corresponding shifts in approach and departure control responsibility can be made. By glancing at the radar display, all controllers can take in most of the facts of the control situation without extensive study before the transition can be made. The coordinator can pitch in and act as a pick-up controller if the traffic gets extremely heavy.

Operational flexibility is similarly provided for at the feeder and final approach controller positions. As the aircraft are lined up at the gate by the feeder controller, they are handed off alternately to either final approach controller. The final approach controller then proceeds to guide the aircraft along a centerline course, and a pre-determined glide-slope. The final approach controller will provide the necessary guidance to the aircraft until the plane is 1/4 mile from the touchdown, and at an altitude of 200 feet. During this talk-down, the second final approach controller is providing the necessary instructions concerning the next aircraft at the gate. The second final approach controller will maintain a three to four mile separation in range from the lead aircraft.

10. AN/TSQ-47 Design Goal Capability

The AN/TSQ-47 system is designed to afford positive control simultaneously over 24 aircraft all approaching, all departing, or in combination. Under normal conditions the landing rate is one aircraft every two and one-half minutes, under heavy loads, and in emergencies; aircraft homogeneous in type may be landed as frequently as one per minute.

SECTION 5

SIF/IFF SYSTEM COMPATIBILITY

This section will supply the existing requirements and recommendations contained in the U. S. National Standard for common system component characteristics approved by the International Civil Aviation Organization.

Compatible system characteristics, three-pulse side lobe suppression, automatic pressure altitude transmission and other improvements were recommended by the ICAO Communications Division.

1. General

Operational requirements for a common Air Traffic Control Radar Beacon System (ATCRBS) have been established to provide, to both civil and military aircraft, a uniform method of safe and efficient regulation of Air Traffic.

2. ATCRBS System Description

The system consists of Airborne Transponders and a ground interrogator, which, in the case of the AN/TSQ-47 system is slaved to the primary search radar system. In operation, an interrogation pulse group transmitted from the ground interrogator-transmitter unit, via the directional Search Radar Antenna assembly, triggers each airborne transponder located in the main beam, causing a multi-pulse reply group to be transmitted from the aircraft. These replies are received on the ground and are demodulated, processed, and decoded, and are then displayed to the controller. Measurement information determines the range (rho) and the main beam direction determines the Azimuth (theta).

The nature of the multiple-pulse reply provides individualized information pertaining to the responding aircraft.

3. Interrogation Modes

The interrogation consists of two (2) transmitted pulses designated P_1 and P_3. An additional control pulse P_2, will be transmitted immediately following the first interrogation pulse P_1.

The internal, measured leading edge to leading edge at half-voltage points, between P_1 and P_3, determines the mode of interrogation and are as follows:

Mode 1 (military)	3 ± 0.2 microseconds
Mode 2 (military)	5 ± 0.2 microseconds
Mode 3/A (Common ATC)	8 ± 0.2 microseconds
Mode B (civil ATC)	17 ± 0.2 microseconds
Mode C (altitude)	21 ± 0.2 microseconds
Mode D (unassigned)	25 ± 0.2 microseconds

The interval between P_1 and P_2 is 2.0 ± 0.15 microseconds, and the duration, or pulse width of P_1, P_2, and P_3 is 0.8 ± 0.1 microseconds. The frequency of the interrogator center is 1030 mc $\pm$ 0.2 mc and the transponder transmitter frequency center is 1090 mc $\pm$ 3 mc/s.

NOTE: The existing military mode 3 and the existing civil mode A, which are identical are combined to form the new mode 3A.

4. Reply Transmission

The reply function consists of a signal comprising two framing pulses spaced 20.3 microseconds measured leading edge to leading edge.

Information pulses are spaced in increments of 2.9 microseconds from the first framing pulse. Designation and position of the information pulses are as follows:

Pulse	Position (microseconds)
A_1	2.9
A_2	5.8
A_4	8.7
B_1	11.6
B_2	14.5
B_4	17.4

A recommendation is being made to include, as part of Mode 3/A, additional information pulses at intervals of 2.9 microseconds starting 1.45 microseconds after the first framing pulse.

Designation and position of these additional pulses is as follows:

Pulse	Position (microseconds)
C_1	1.45
C_2	4.35
C_4	7.25
X (required for future use)	10.15
D_1	13.05
D_2	15.95
D_4	18.85

5. Special Position Identification Pulse (SPI)

In addition to the information pulses provided, a special Identification Pulse, which may be used with any of the other information codes upon request, is provided at a spacing 4.35 microseconds following the last framing pulse. Some transponders may repeat the reply code in lieu of the identification pulse.

6. Special Codes

Special provisions for transmission of a distinct emergency and a communications failure response is provided (Code 76, Mode 3A)

7. Emergency

Code 77 is used on mode 3/A to provide recognition of an aircraft emergency.

NOTE: Military aircraft will transmit Code 77 in the first train of a four train emergency response. Some civil transponders will repeat the mode 3/A code three times in lieu of Code 77.

8. Code Nomenclature

The code designations consists of digits which lie between 0 and 7, inclusive, and consist of the sum of the sub-scripts of the pulse numbers employed as follows:

Digit	Pulse Group
First (most significant)	A
Second	B
Third	C (recommendation)
Fourth	D (recommendation)

Examples:

1. Code 36 would consist of information pulses A_1, A_2, B_2, B_4, (last two digits omitted where 64 or less codes are used)

2. Code 2057 would consist of A_2, C_1, C_4, D_1, D_2, D_4.

9. Reply Codes

Pressure - altitude transmission codes are automatically selectable for reply to mode C interrogation containing the aircraft altitude.

When interrogated on mode C for aircraft pressure - altitude transmission, the reply consists of the two framing pulses, and combinations of the ABCD and special position identification pulses (SPI).

Independent of the modes and codes manually selected, the transponder should reply to mode C interrogations with automatically

selected combinations of 11 information pulses (ABCD) and Special Position Identification Pulse (SPI) coded in binary form in 100 foot increments. Up to nine of the pulse positions are used to encode a range of 128,000 feet in 500 foot increments; up to 2 of the remaining pulse positions are used to report in 100 foot increments. The pressure altitude setting is referenced to the standard pressure setting of 29.92 inches of mercury (1013.2 millibars).

10. Illustrations

Figure 7 shows the transponder reply pulse assignment, and Tables 1 and 2 show the altitude coding assignments.

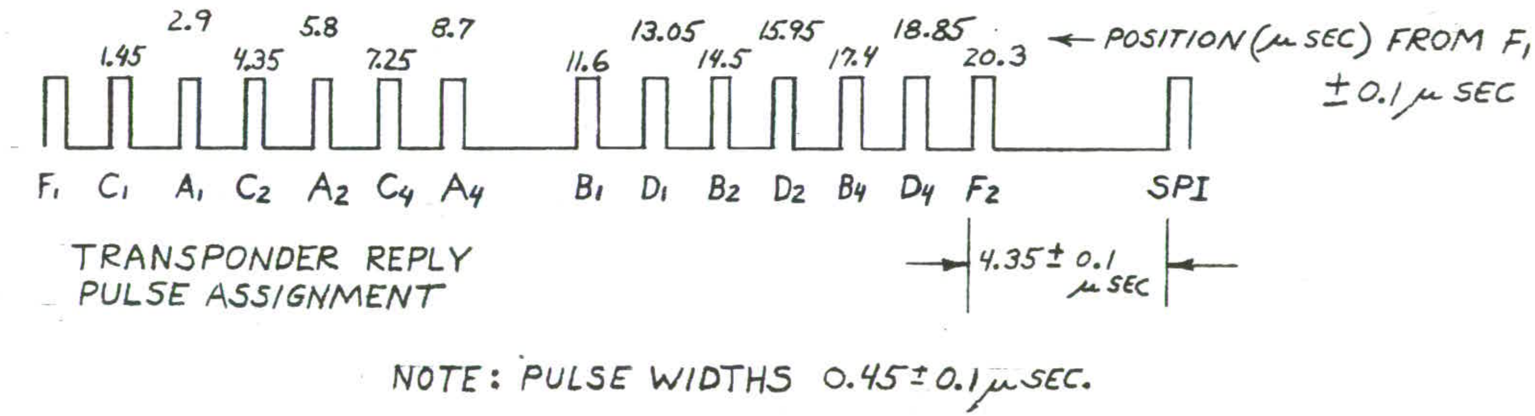


FIGURE 7. TRANSPONDER REPLY PULSE ASSIGNMENTS

$A_4B\ B_2B_4$ Pulses*

$D_2D_4A_1A_2$ Pulses

	0000	0001	0011	0010	0110	0111	0101	0100	1100	1101	1111	1110	1010	1011	1001	1000
0000	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0001	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
0011	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
0010	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48
0110	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
0111	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80
0101	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
0100	127	126	125	124	123	122	121	120	119	118	117	116	115	114	113	112
1100	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
1101	159	158	157	156	155	154	153	152	151	150	149	148	147	146	145	144
1111	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
1110	191	190	189	188	187	186	185	184	183	182	181	180	179	178	177	176
1010	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
1011	223	222	221	220	219	218	217	216	215	214	213	212	211	210	209	208
1001	224	225	226	227	[illegible]	229	230	231	232	233	234	235	236	237	238	239
1000	255	254	253	252	251	250	249	248	247	246	245	244	243	242	241	240

256 increments
(500 feet each)
Giving height
from - 1000
to 127,000 feet

Table 1.

(Unit Distance Reflected Binary [Gray Code] for 8 Bits)

*0 or 1 in a position indicates the absence or presence of a pulse respectively

100 FOOT PULSES			SUM OF DIGITS OF GRAY CODE	
C_1	C_2	C_4	ODD	EVEN
0	0	1	7	8
0	1	1	6	9
0	1	0	5	0
1	1	0	4	1
1	0	0	3	2

(100 Foot Increments)

SECTION 6

Recommendations for Improvement of Communications Control and Audio Distribution

1. General

The following recommendations are made for the improvement of communications control and audio distribution within a number of shelters (subsystems) of the AN/TSQ-47. The recommendations primarily refer to the AN/TSW-5; however, since standardization is recommended for all shelters, the recommendations apply to the AN/TSW-6, AN/TPN-14, and the AN/TPS-35 as well.

2. Standardization of Communications Control Recommended for All Shelters

The AN/TSQ-47 has four shelters (subsystems) which must provide communications control and audio distribution for two or more air-ground-airand intershelter radio voice communications channels. These shelters are the AN/TSW-5, AN/TSW-6, AN/TPN-14, and AN/TPS-35. A different approach toward communications control and audio distribution is employed in each shelter. It is recommended that a standardized method of communications control and audio distribution be considered for all shelters. It is also recommended that the standards be tailored to methods employed in the AN/TSW-5, with improvements recommended in the following paragraphs.

3. Modification of key-audio box

In the AN/TSW-5, each operator is provided with a communications selector box and a key-audio box. The communications selector box makes provisions for the selection of the desired radio channel, and the key-audio box makes provisions for connecting the headset-

microphone, keying the transmitter(s), and setting the receive level to the headset.

In the present configuration, the microphone preamplifier is contained in the communications selector box. It is recommended that the preamplifier be removed from the communications selector box and be placed in the key-audio box. This should reduce hum and interference since the low level microphone signal from the key-audio box to the communications selector box would be eliminated and be replaced with the relatively high level output of the microphone preamplifier.

In order to accomplish this satisfactorily, the microphone preamplifier should be slightly modified. The present preamplifier has an output impedance of 4000 ohms (transformer output). The transformer should include a 150 ohm output, and the connections should be carried to the preamp. connector receptacle in a manner that would enable the output to be floated (balanced with respect to ground) if desired. The balanced output and lower output impedance reduces the possibility of hum and interference. The associated amplifier in the communications selector box into which the preamplifier works is already equipped with a 150 ohm floating input.

Placing the microphone preamplifier in the key-audio box will result in a slight increase in size of the key-audio box, but with proper packaging, the added size should not create any serious installation difficulties.

4. Modification of Communications Selector Box to Allow Duplex Operation

In the present communications selector box in the AN/TSW-5, only one audio power amplifier is supplied. During transmission, the

audio power amplifier must operate in conjunction with the microphone preamplifier in order to provide enough power to modulate the transmitter(s). During reception, the amplifier is switched so as to act as a receiver mixing amplifier. As a result, the communications selector box does not make satisfactory provisions for operating with duplex communications systems such as RACEP and telephone. In addition, the operator cannot monitor transmitter sidetone during transmission.

In order to overcome the above difficulty, it is recommended that an additional amplifier be included in the communications selector box. This amplifier could be placed mainly in the space left vacant when the preamplifier was moved to the key-audio box (see par. 3). Since the amplifier is slightly larger than the preamplifier, a small amount of repackaging will be required

5. Improvement of Speaker Audio Control

The audio signals to the speaker should be controlled in a manner that will result in minimum interference and maximum efficiency of the operator.

In the present configuration, the speaker is equipped with an independent volume control. It is recommended that the volume control for the headset amplifier (located on the key-audio box) also control the level to the speaker. This reduces the number of controls the operator has to adjust to obtain the proper output levels at the headset and speaker, and also automatically maintains the same relative level between the headset and speaker. The speaker should have a screwdriver adjustment to set the relative output level.

When transmitting on simplex circuits, the input to the speaker should be shut off or greatly attenuated in order to reduce the possibility of audio distortion and interference caused by feedback from the speaker

to the microphone, as a result of sidetone from the transmitter.

6. Shielded Transformers Recommended for Preamplifiers and Amplifiers

A great deal of difficulty was encountered with 400 cps hum in the audio distribution circuits in the AN/TSW-5. Investigation revealed that one contributing factor was the lack of shielding of the transformers in the audio amplifier. It is recommended that, in the future, the microphone preamplifier and audio amplifier be equipped only with transformers that are electrically and magnetically shielded.

7. Modification of Communications Selector Box to Enable Operation With Telephone Lines

In the present configuration, the AN/TSW-5 communications selector boxes have no provisions to enable the operator to communicate over telephone circuits by means of his headset microphone. It is recommended that this feature be added on future models of the communications selector box.

An improved communications selector box (vertical type) is shown in Figure 9. A two position telephone lever switch has been added on the lower portion of the control panel. In the OFF position, the telephone earpiece circuit from the telephone keybox (See Section 7, para. 12) is disconnected from the input of the communications selector box headset-mixer amplifier and the telephone microphone circuit is disconnected from the output of the microphone amplifier. In the ON position, the telephone microphone and earpiece circuits are connected to the respective microphone and headset amplifiers in the communications selector box. This enables the operator to employ his headset-microphone to communicate over any tel ephone line which is selected at his telephone keybox.

In order to provide connections to the telephone keybox, a connector must be added on the communications selector box. In addition, if impedance matching or AC isolation is required in order to provide satisfactory connections with the telephone keybox, the additional components should be included in the communications selector box. A transistor amplifier stage may be required for the earpiece signal.

8. Modification of Communications Selector Box to Provide Improved Indication and Control

The AN/TSW-5 is equipped with vertically mounted and horizontally mounted communications selector boxes. The functions of both types are identical. An illustration of the present vertical communications selector box is shown in Figure 8. For the designated channels A through H, each channel is provided with a three position lever switch which provides the options of transmit-receive (TR), receive (R), and OFF. One indicator lamp is provided to given an indication of transmission (keying) from any other control position on the respective channel. A label slot is also provided to give the channel designation (A, B, C, etc. in the illustration) and other pertinent information such as frequency.

In addition to the above, a rotary switch is provided to enable selection of any one of the remaining channels which cannot be controlled by means of a lever switch.

An illustration of the recommended improved version of the vertically mounted communications selector box is shown in Figure 9. In addition to providing improved indication and control, it also has facilities to enable the operator to communicate over the telephone lines by means of his headset microphone as was discussed previously. It should be noted that all recommendations for the vertical selector

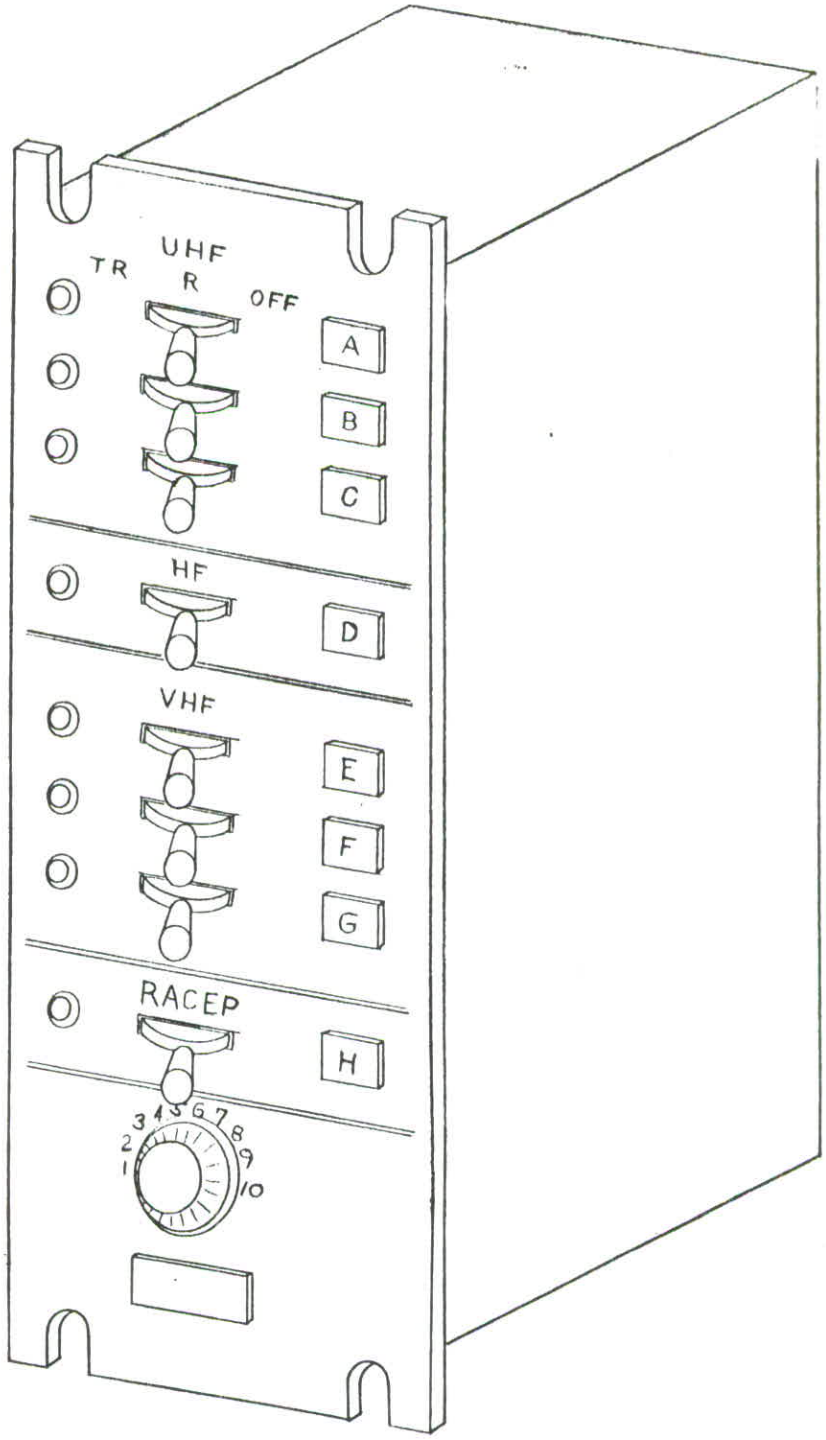


FIGURE 8: Present Configuration of Vertically Mounted Communications Selector Box

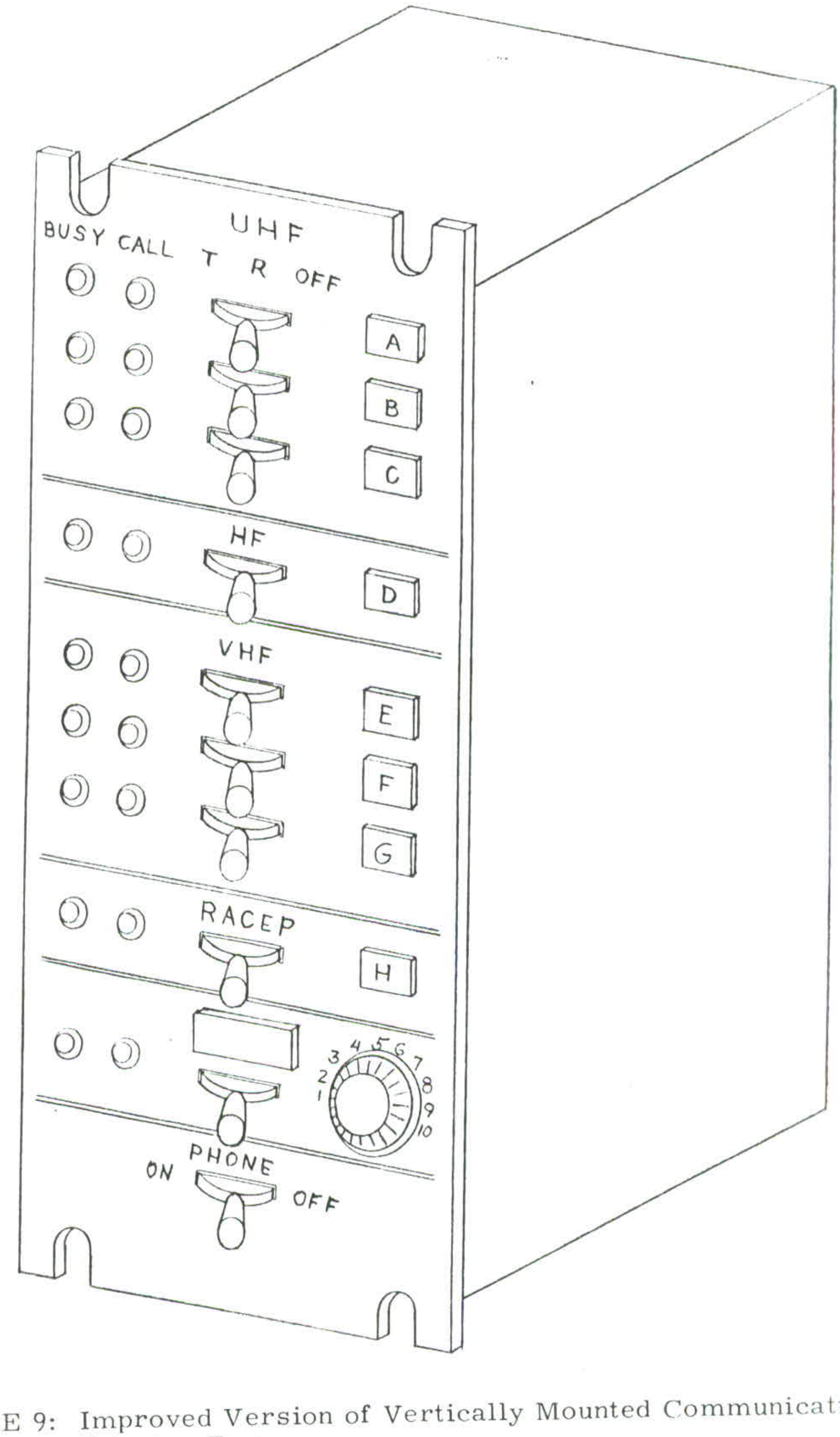


FIGURE 9: Improved Version of Vertically Mounted Communications Selector Box.

box also apply to the horizontal selector box. The improved control and indication functions are discussed in the following paragraphs.

a. BUSY lamp

The BUSY lamp should illuminate when the associated transmitter is keyed from any other communications selector box, provided the lever switch at the selector box under discussion is in the RT (receive-transmit) position. This will indicate when the transmitter is busy as a result of being keyed from any other position, and will also indicate if another operator breaks in on the transmission. When the lever switch is not in the TR position, the lamp should be inoperative. This feature relieves the operator from being bothered by BUSY lamps on channels on which he does not desire to transmit. When any BUSY lamp is illuminated at his selector panel, this will be a signal to the operator not to key the transmitter since the BUSY lamp will only be illuminated, during transmission from another position, on channels on which the operator is ready to key his transmitter.

The present communications selector box provides a lamp which is illuminated when a transmitter on a given channel is keyed from another position; however, the lamp is illuminated regardless of the position of the associated lever switch.

b. CALL lamp

The CALL lamp should be illuminated when an outside call is received. However, the lamp should only be illuminated for a call, at a given selector box, when the associated lever switch is in the R (receive) or TR (transmit-receive) position. When the switch is in the OFF position, the lamp should be inoperative. This will relieve the operator from being bothered by CALL lamps on channels which he is not monitoring. The lamp should not illuminate when a call on the channel originates at the AN/TSW-5.

The lamp should be positively controlled by the receiver in conjunction with squelch operation. Present receivers do not provide a circuit for this function; however, it is felt that this could be provided with relatively simple modifications of the receivers. At most, the modification would involve only one or two transistors and associated components, and possibly a relay. In the event that modification of the receivers proves unfeasible, an electronically controlled voice operated relay could be provided for each channel. This would be external to the associated receiver and could be in the form of a plug-in module.

The present communications selector box in the AN/TSW-5 does not make provisions for CALL indication. CALL indication is provided in the AN/TSW-6, but the indicator lamps are not mounted on the communications selector box and positive control via the receiver squelch is not provided.

c. LABEL Lamp.

The LABEL lamp should provide identification of the channel associated with the lever switch and BUSY and CALL lamps. When "on", the LABEL lamp illuminates a translucent card with writing which gives the operating frequency of the radio equipment and/or channel designation.

The LABEL lamp should be illuminated when the equipment (associated receiver and transmitter) is turned "on" and the associated lever switch is in the R or TR position. The lamp should not be illuminated when the lever switch is in the OFF position or the radio equipment is turned "off". The above features would serve to indicate that the equipment (receiver and transmitter) being utilized is actually turned "on", and would also relieve the operator from being bothered by label lamps for equipment he is not actually utilizing.

The label indication on the present communications selector

box in the AN/TSW-5 provides all of the above features except one. It remains illuminated regardless of whether the associated receiver and transmitter is "off".

d. Rotary selector switch.

The rotary selector switch enables the operator to select any one of the remaining channels which cannot be controlled directly by a lever switch. The channel can then be controlled by the adjacent lever switch in the same manner as the other channels which are connected directly to lever switches. The adjacent BUSY and CALL lamps also provide the same indications as are provided on the other channels. The label slot is located directly above the lever switch and should make provisions for identifying the channel selected by the rotary switch. The ideal approach would be to provide a drum or tape behind the label slot which would move in conjunction with the rotary switch to identify the selected channel. The label illumination should be controlled in the same manner as for the other channels on the selector box.

The rotary switch on the present communications selector box does not provide a BUSY or CALL indication for the selected channel. In addition, no provisions are made for separate R (receive) and TR (transmit-receive) options on the selected channel.

9. Additional Improvements Which Would Require Extensive Redesign

The communications control and audio distribution facility in the AN/TSW-5 could be further improved by relocation of all amplifiers (except microphone preamplifiers) and relays to the communications junction box. This should allow some reduction in the physical size of the communications selector box and a great reduction in the number of wires (especially twisted shielded pairs) to the selector box. Control

would be accomplished by relays in the junction box which would be actuated by operation of associated switches at a given communications junction box and the consequent reduction in audio wiring within the shelter should result in reduced hum and crosstalk.

Unfortunately, to accomplish the above results and maintain the flexibility of the present system may require an excessive number of relays. For each selector box, a relay will be required for each channel for selecting the receive option, and a relay for each channel for selecting the transmit option. Since each selector box has the capability of selecting from among 16 channels, this means that 32 relays will be required in the communications junction box for providing control for a given selector box. The AN/TSW-5 contains nine communications selector boxes which results in a requirement for a total of 288 relays in the communications junction box for audio switching alone. Additional relays may be required for transmitter keying functions.

Since most cable runs in the AN/TSW-5 are less than 50 feet, it appears that the additional relays required are not worth the reduction in cabling that could be obtained. The only justification would appear to be in circumstances where the hum and crosstalk is desired to be much less than the levels in the present configuration.

10. Addition of Interphone Capability to Communications Selector Box

A discussion concerning the addition of interphone capability to telephone equipment in the AN/TSW-5 is presented in Section 7, paragraph 13. As another option, it would be possible to add interphone capability to the communications selector box rather than to the telephone equipment. This could be accomplished by the addition of pushbutton switches to enable selection of any one of the nine operator positions.

SECTION 7

Recommendations for Improvement of Landlines Subsystem

1. General

The following recommendations are made for the improvement of the landlines subsystem employed within the AN/TSQ-47. Most of the recommendations require changes or additions which can be made without a major redesign of the present equipment; however, the recommended interphone capability will require additional equipment and design.

2. Automatic Transfer of Telephone Equipment From Normal Shelter DC to Emergency Battery Source.

Under the present configuration in the AN/TSQ-47, the landlines subsystem has no provision for transfer from the 28 vdc shelter supply to emergency battery source in either the AN/TSW-5 or the AN/TPN-14 shelters. Manual transfer to emergency battery is provided in the AN/TSW-6 shelter.

It is recommended that provisions be made for automatic transfer of the telephone equipment to emergency battery when the shelter 28 vdc is lost due to generator failure. This feature can be provided with a very small modification of the present equipment as is shown in Figure 10. The equipment is connected to each supply by means of diodes and operates from the supply with the higher voltage. Normally, the shelter dc supply voltage is 28 v and the emergency battery voltage (available when generator fails) is 24 v. The diodes also prevent either of the supplies from supplying current to ground through the source impedance of the other.

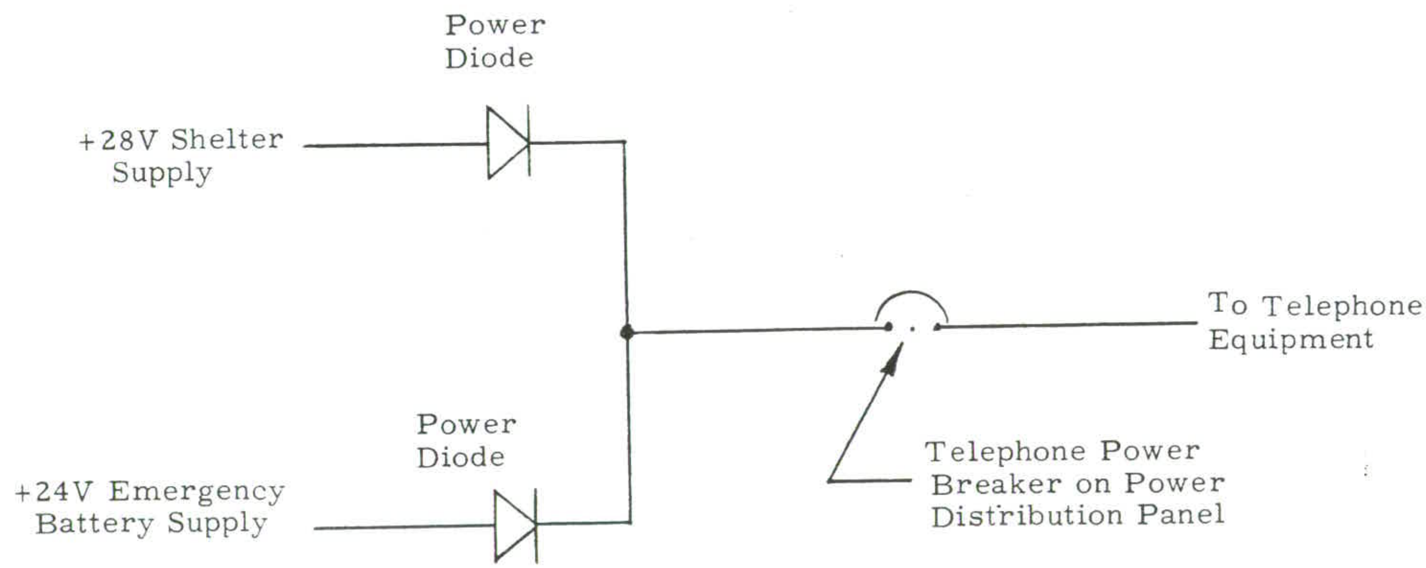


FIGURE 10: Method of Providing Automatic Power Transfer for Telephone Equipment

3. <u>Requirement for Improved Dial Module in Telephone Equipment in AN/TSW-6</u>

The two-line telephone keyboxes are provided with a plug-in dial module which has the face of the dial set at approximately 45 degrees relative to the face of the keybox. This arrangement is satisfactory as long as the face of the keybox is mounted in a hroizontal position; however, in the AN/TSW-6 the face of the keybox is mounted at an angle relative to the horizontal and this causes the face of the dial to be placed in a vertical position.

It is recommended that the telephone keyboxes in the AN/TSW-6 be equilped with a dial module which provides a more convenient slope of the dial face.

4. <u>Routing of DC Power to Keyboxes</u>

In the present configuration, part of the dc power to each telephone keybox is routed directly from the main telephone breaker on the shelter power distribution panel, and the remainder comes via the telephone relay frame. For equipment and circuits associated with a given telephone line, a separate dc power fuse is provided in the relay frame and if an overload causes the fuse to blow, only one line will be disabled. However, if an overload occurs in any keybox circuit which is supplied from the main telephone breaker, the complete telephone system will be disabled.

It is recommended that the telephone circuits be modified so that all dc power to equipment and circuits associated with a given telephone line be supplied via the associated fuse in the relay frame, and that the dc supply circuit from the main telephone breaker to the keyboxes be deleted.

It should be noted that deletion of the (dial) illumination voltage to each keybox is not recommended.

5. Control of Dial Illumination

The keybox has provisions for dial illumination voltage to be provided from an external source and this feature is quite satisfactory; however, it is felt that the dial does not have to be illuminated unless the calling party is employing it to dial a number. In many instances, one or more local battery lines may be utilized and the dial will not be needed for these lines. It is therefore recommended that a switch be placed on the dial module to enable the illumination to be extinguished when not required.

6. Plaque for Identification of Lines

Each keybox is equipped with a plug-in module for each of the available lines. The module makes provision for identification of its associated line by means of a metal tag which is labeled "line 1", "line 2", etc. It is felt that a more positive identification of the lines should be available. This should take the form of a plaque on which the line designation can be written in pencil, or a label slot with a transparent cover in which a card with the line designation can be inserted.

In addition, it is felt that the plaque should be illuminated by a lamp on the module. The lamp voltage would come from the same source as the illumination voltage for the dial module, but the lamp should not be capable of being turned "on" or "off" at the keybox.

7. Strain Relief for Binding Posts, and Telephone Wires

The rear of the telephone entry panel is equipped with binding posts for the twisted pairs which route the telephone signals to the relay frame in the shelter. The wires are routed directly to the terminals with no clamps provided for strain relief. It is recommended that a clamp or other means be provided for strain relief of these wires.

easily handled by one person.

11. Telephone Reel Assembly

In the three shelters containing telephone equipment, no equipment is provided to aid in the laying of the telephone field wire. It is recommended that an assembly be provided to aid in the laying of the field wire by one or two persons on foot or in a vehicle. The assembly should be small and light weight and should be capable of being stored without difficulty.

12. Provision for Interconnecting Telephone Microphone and Earpiece Circuits Between Telephone Keybox and Communications Selector Box.

The communications selector boxes in the AN/TSW-5 and the AN/TSW-6 have no provisions for enabling the operator to conduct telephone communications by means of his headset-microphone. To accomplish this requires a modification of both the communications selector box and the telephone keybox. The required modification of the communications selector box is discussed in Section 6, para. 7. The required modification of the telephone keybox is discussed in the following paragraphs.

The keybox should include a connector which will enable voice telephone communications to be conducted by means of the headset-microphone utilized with the communications selector box. The connector should make provisions for external connections in parallel with the telephone handset microphone and earpiece. If impedance matching components are required to match the communications selector box circuits to the telephone circuits, these items should be provided in the communications selector box.

Connections should be provided to enable the audio output of the

microphone amplifier in the communications selector box to be paralleled with the circuits to the telephone handset microphone. The telephone keybox should provide isolating capacitors to prevent the DC microphone supply from being affected by the external circuits. Additional connections should be provided to enable the audio input to the headset amplifier and the speaker amplifier to be connected in parallel with the circuit to the telephone handset earpiece. The connector should also make provisions for the required shield connections.

Since, under the preceding conditions, the telephone handset microphone will be "live" and could cause interference with telephone communications carried on by means of the operator's headset-microphone, a method of disabling the dc to the hanset microphone (when not in use) should be provided. This could be accomplished by means of a telephone hookswitch, or by means of the telephone ON-OFF switch on the communications selector box. A simpler method would be to disconnect the telephone handset from the telephone keybox when the headset-microphone is employed. In fact, the keybox connector receptacle for the handset connector plug could be employed to interconnect the communications selector box. Another approach would be to provide a press-to-talk switch on the telephone handset.

13. Addition of Interphone Capability to Telephone Equipment in the AN/TSW-5

During field tests, USAF operating personnel suggested that greater operational efficiency could be attained if interphone capability were available between the various operators in the AN/TSW-5. As a result, it is recommended that the telephone equipment be designed to include this feature.

Since the telephones have dial capability, it is recommended that the intercommunications feature be designed to take advantage of this

condition. The telephone keybox should have lever switches for selection of the interphone function. Each lever switch should be mounted on a module in the same manner as the lever switches for selecting telephone lines. Each operator provided with interphone capability should have the option of selecting from at least two interphone channels to reduce the possibility of a busy interphone channel delaying intrashelter communications. This means that the three-line keyboxes in the AN/TSW-5 should have at least two additional lever switches, or modules; and operator positions which previously had no telephone facilities, and now require interphone capability, will require the addition of at least a two-line keybox such as is used in the AN/TSW-6.

The telephone relay frame will require additional (interphone) modules to perform the required switching, signaling, and impedance matching. Each module should contain a ten position stepping switch so that the party calling on interphone may dial any one of the other interphone positions. The module should select the called party, provide a CALL indication at his keybox only, provide a BUSY indication to all keyboxes, and switch in circuits that will enable the calling and called parties to conduct voice communications over the interphone circuit. When the call is completed and the associated lever switches at each keybox are returned to the OFF position, all circuits should be restored to the initial condition.

If facilities for four interphone circuits were provided, this would provide for simultaneous communications between four parties, or eight persons. This is probably the maximum capacity that would ever be required since there is a maximum of nine persons required in the shelter at any one time.

14. Improvement of Landline Entry Panel

The present landline entry panel is equipped with a hinged cover to protect the telephone binding posts and various components from the elements. The cover is not completely water tight, especially when telephone lines are attached, and water tends to accumulate in the entry panel housing during a driving rain. Unfortunately, the housing is so designed that the water cannot drain from the bottom of the housing and an accumulation of water tends to remain until dissipated by evaporation. It is recommended that the bottom of the housing be designed to allow water to drain from the entry panel with a minimum of accumulation.

SECTION 8

Improvement in Isolation of VHF and UHF Communications Equipments by Addition of Hybrid Couplers

1. General

In the present configuration of the AN/TSQ-47, up to three VHF receiver-transmitter units are coupled to a common VHF antenna by means of a VHF multicoupler, and up to four UHF transceivers are coupled to a common UHF antenna by a UHF multicoupler. Both the VHF and UHF couplers employ high Q cavities to obtain isolation between equipment, and the amount of isolation depends upon the frequency separation. With the UHF coupler the isolation is approximately 40 db for two megacycles separation and approximately 60 db for six megacycles separation. By the addition of hybrid couplers, approximately 30 db additional isolation could be obtained for equipments on a common antenna. Also, the isolation obtained from a hybrid coupler is not dependent on frequency separation; the 30 db isolation can be obtained even if equipments are on identical frequencies. Another advantage of the hybrid coupler is that no tuning is required.

2. Theory of Operation of Hybrid Coupler

The hybrid coupler is used for coupling a number of radio equipments (receivers, transmitters, or R/T units) to one antenna. The UHF hybrid can be compared to the regular telephone hybrid except for the fact that the frequency coverage is in the VHF or UHF range rather than at audio frequencies.

a. Transmission

Figure 11 is a schematic showing the analogy of a telephone hybrid to a two input hybrid coupler. The schematic shows an unbalanced (relative to ground) hybrid; telephone circuits normally use balanced hybrids.

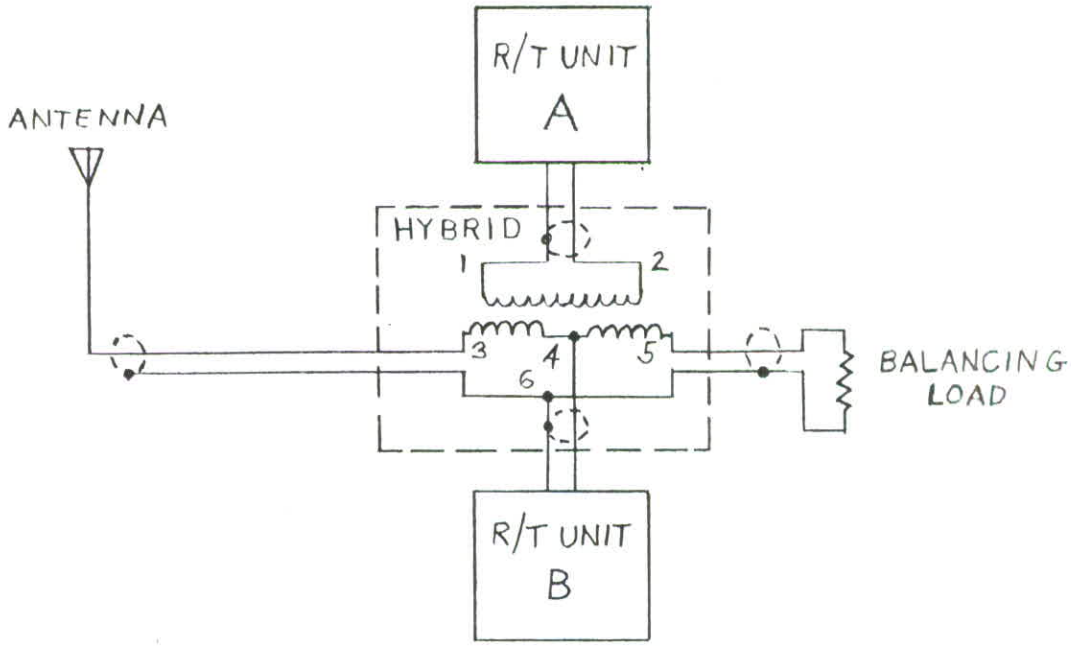


FIGURE 11: Schematic Showing Analogy of Telephone Hybrid to Two Input Hybrid for Coupling Two R/T Units to One Antenna

The hybrid is essentially a bridge transformer. Consider R/T unit A which is connected to terminals 1 and 2. When A is transmitting, the voltages developed across terminals 3-4 and 4-5 will be equal and if the balancing load and the antenna impedance are equal, half the power will be absorbed by the load and the other half will be radiated by the antenna and no power will go to R/T unit B. When R/T unit B is transmitting, the split transformer causes magnetic fields to be induced in phase opposition and no power will go to R/T unit A; half the power will be absorbed by the load and the other half will be radiated. The results are the same when both R/T units are transmitting simultaneously except that the load must absorb twice as much power. It should be noted that a loss of 3 db in transmitter power is encountered by utilizing the two input hybrid coupler.

b. Reception

During reception, the antenna can be considered a generator with inputs across terminals 3 and 6. The current flow through the 3-4 section of the transformer will induce a voltage across 4-5 which is equal to the voltage drop across 4-6 (R/T unit B). As a result, no current will flow through the balancing load. A voltage will be induced across 1-2 as a result of the current flow in 3-4. The net result is that half the power will go to R/T unit A and the other half will go the R/T unit B. Note that this results in a 3 db loss to a given receiver as a result of using the hybrid coupler.

c. Isolation.

Ideally, the hybrid coupler would appear to provide perfect isolation. Unfortunately, this is not the case. Capacitive coupling can occur, and the transformer may not be perfectly balanced throughout the frequency range. In general, the hybrid coupler can provide a minimum of 25 db isolation throughout the 225 to 400 mc frequency range with maximum

isolation increasing to above 40 db at certain frequencies. The nature of the hybrid coupler is such that at least the minimum isolation is provided even when the R/T units are on the same frequency. The antenna used with the hybrid coupler must provide a constant impedance throughout the frequency range in order to obtain the maximum available isolation. The antenna should not be placed near objects which could affect the impedance.

d. Four Input Hybrid

A combination of three hybrids may be used to couple four R/T units to one antenna. This is indicated in Figure 12. The theory is the same as previously except that the hybrids to which the R/T units are attached now feed into another hybrid instead of directly to the antenna. As a result of going through two hybrids instead of one, the losses will be 6 db instead of 3 db. It should be noted that the losses mentioned in this discussion are theoretical, in actual practice, these losses will be slightly exceeded.

3. Typical UHF Hybrid Coupler

According to information received from a typical manufacturer, UHF hybrid couplers with the characteristics shown in Figure 13 can be constructed. No information was provided on the standing wave ratio that would be introduced by the coupler; however, this would probably be small.

The couplers would have internal balancing load resistors and the size would be less than 1 cubic foot and the weight would be less than 20 pounds. As can be seen, the couplers would couple four R/T units to one antenna.

VHF hybrid couplers can also be constructed with approximately the same characteristics.

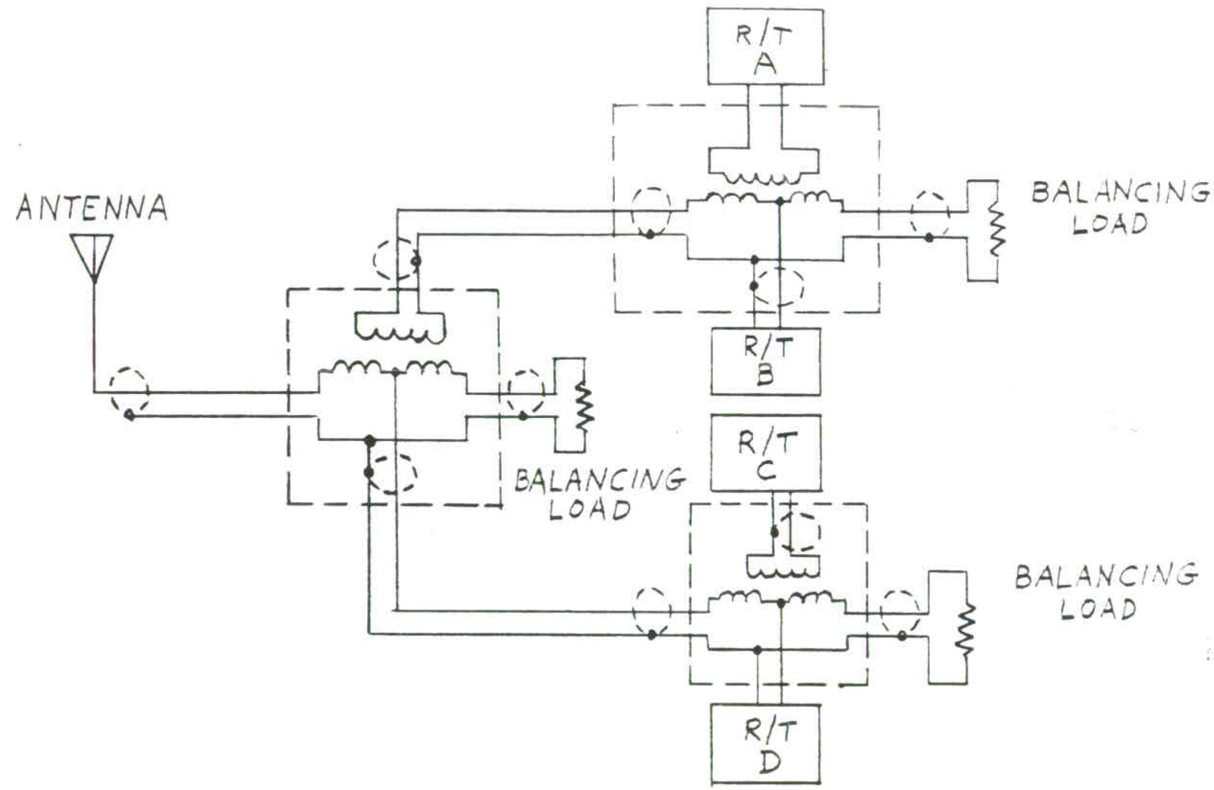
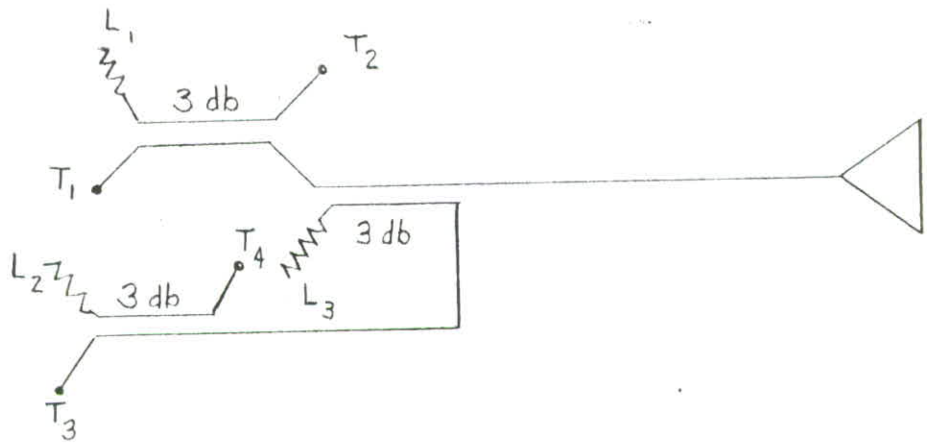


FIGURE 12: Schematic Showing Method of Utilizing Three Hybrids to Couple Four R/T Units to One Antenna.



T_1 R/T unit No. 1
T_2 R/T unit No. 2
T_3 R/T unit No. 3
T_4 R/T unit No. 4

L_1 Balancing load No. 1
L_2 Balancing load No. 2
L_3 Balancing load No. 3

Antenna Coupling (loss)

T_1 7 db (approx.)
T_2 7 db (approx.)
T_3 7 db (approx.)
T_4 7 db (approx.)

Dissipation (25 watt transmitters)

L_1 37.5 watts (approx.)
L_2 18.8 watts (approx.)
L_3 18.8 watts (approx.)

Isolation (db)

	T_1	T_2	T_3	T_4
T_1	--	25	31	31
T_2	25	--	31	31
T_3	31	31	--	25
T_4	31	31	25	--

FIGURE 13: Characteristics of Typical UHF Hybrid Coupler for Coupling 4 R/T Units to One Antenna.

4. Recommended Method of Adding Hybrid Couplers

The major advantage of the hybrid coupler is that the isolation obtained is independent of frequency separation and no tuning is required. The major disadvantage is the losses encountered in the coupling process (over 6 db for a four input coupler). Although hybrid couplers could be added in place of the present tuned-cavity type multicouplers, it is doubtful that sufficient isolation could be obtained. It is therefore recommended that the hybrid coupler be installed to work in conjunction with the multicouplers that are presently employed.

a. Addition of UHF Hybrid Coupler

Figure 14 shows the present method of coupling four UHF R/T units to one antenna by means of a UHF multicoupler. Each R/T unit feeds through manually tuned tandem coaxial cavities to a combining network where all four signals are combined for application to the UHF antenna. Figure 15 shows how a UHF hybrid coupler could be added to work in conjunction with the UHF multicoupler. This requires that the combining network in the multicoupler be eliminated (or bypassed) and a separate output connector be provided for each tandem cavity. The four signals are then combined in the hybrid coupler for application to the UHF antenna. This results in approximately 30 db additional isolation (regardless of frequency separation) between the R/T units coupled to the same antenna.

b. Addition of VHF Hybrid Coupler

Figure 16 shows the present method of coupling three VHF receiver-transmitters to one antenna by means of a VHF multicoupler. Each receiver-transmitter feeds through a single cavity (A, B, or C) the outputs of which are combined for application to the VHF antenna. Figure 17 shows how a VHF hybrid coupler could be added to work in

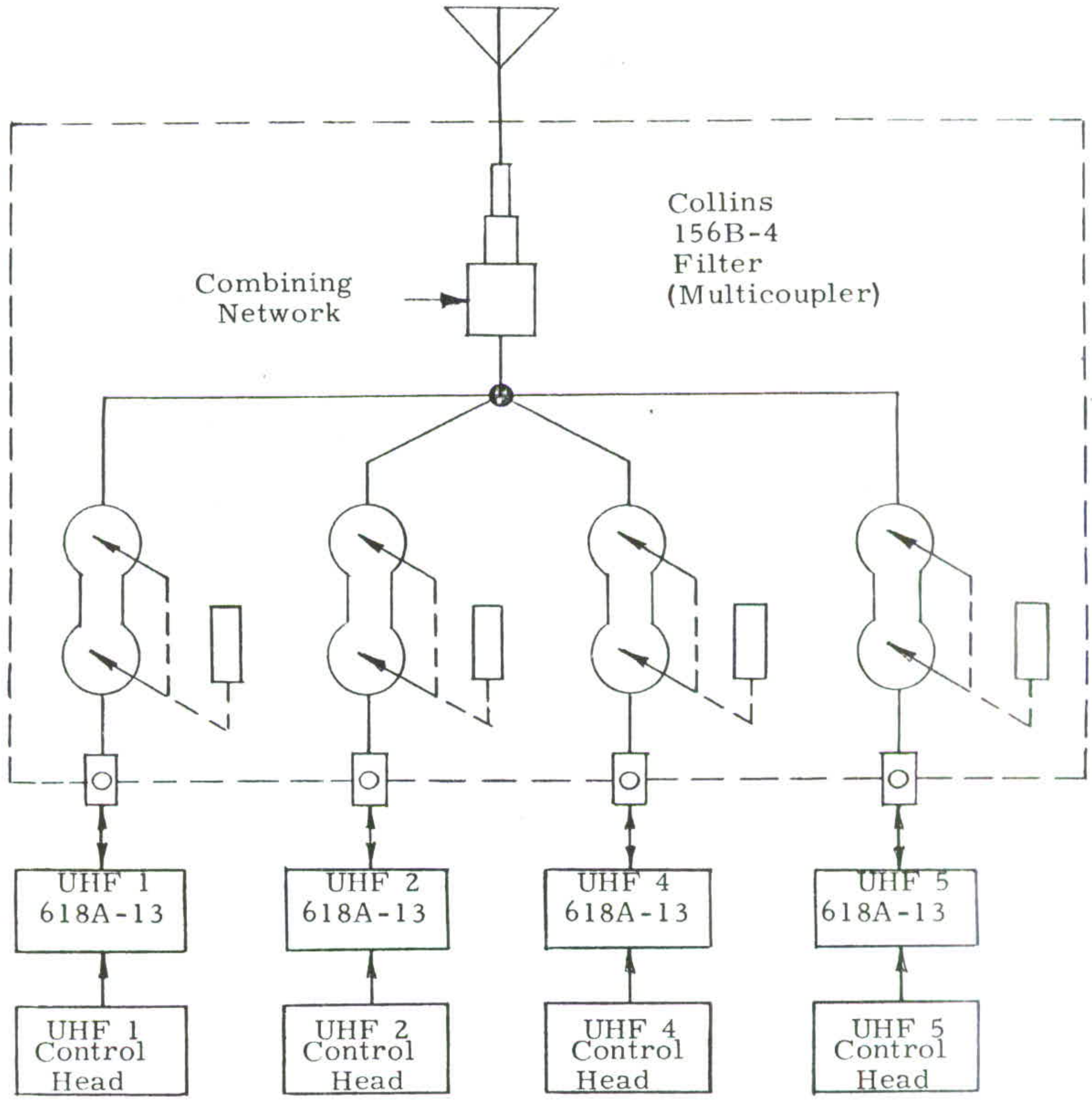


FIGURE 14: Present Method of Coupling Four UHF R/T Units to One Antenna by Means of UHF Multicoupler.

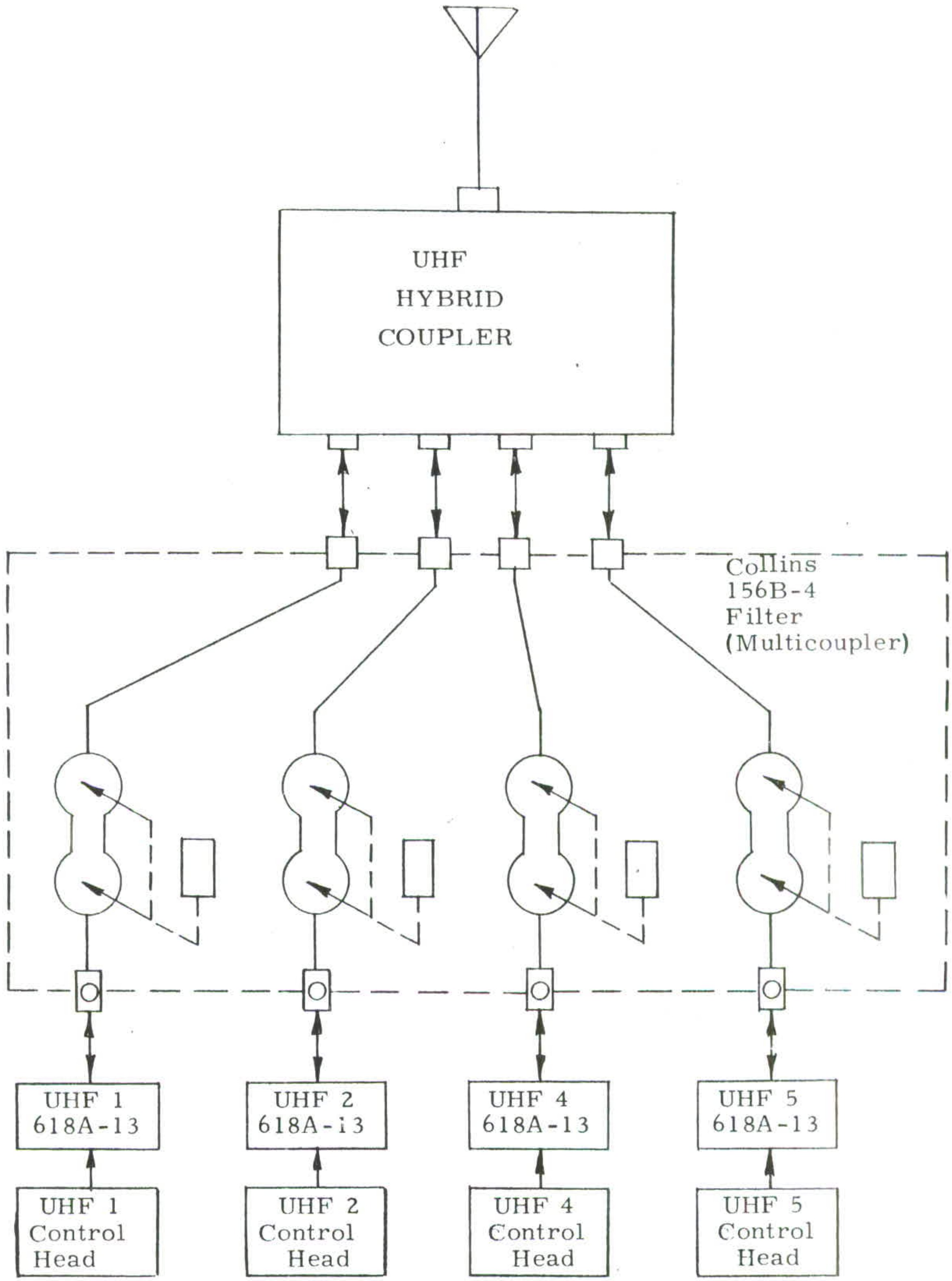


FIGURE 15: Recommended Method of Providing Additional Isolation by the Addition of UHF Hybrid Coupler to Operate in Conjunction with UHF Multicoupler

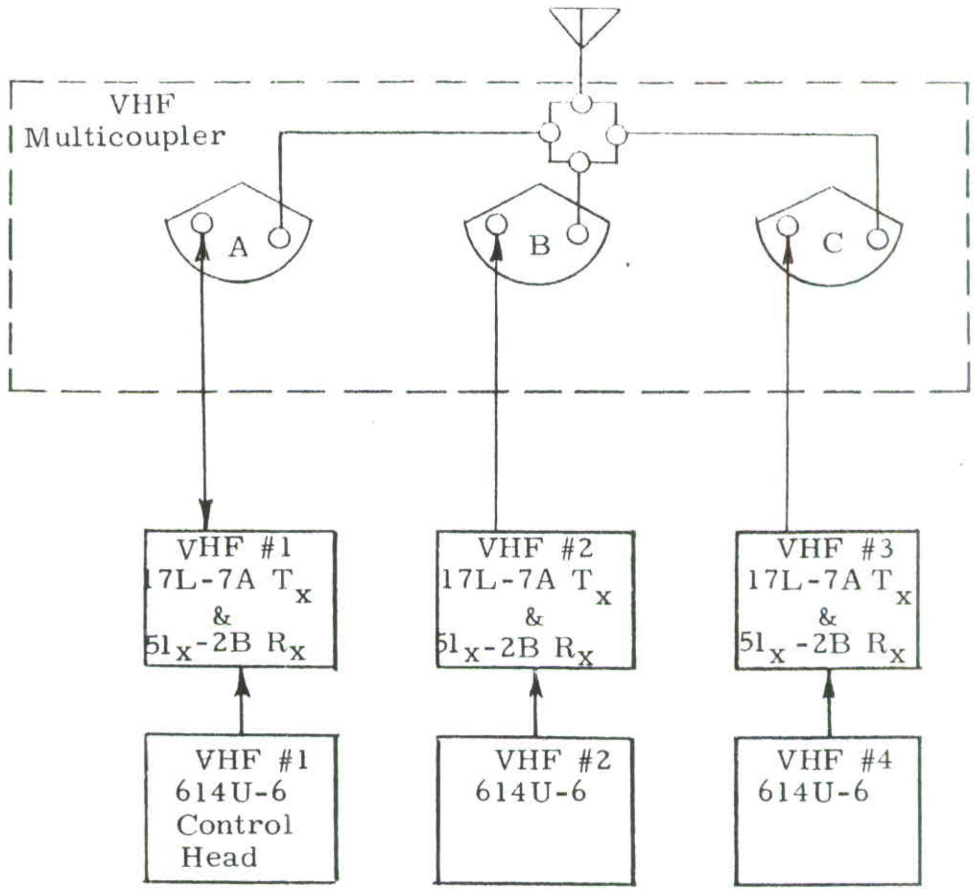


FIGURE 16: Present Method of Coupling Three VHF Receiver Transmitters to One Antenna by Means of VHF Multicoupler.

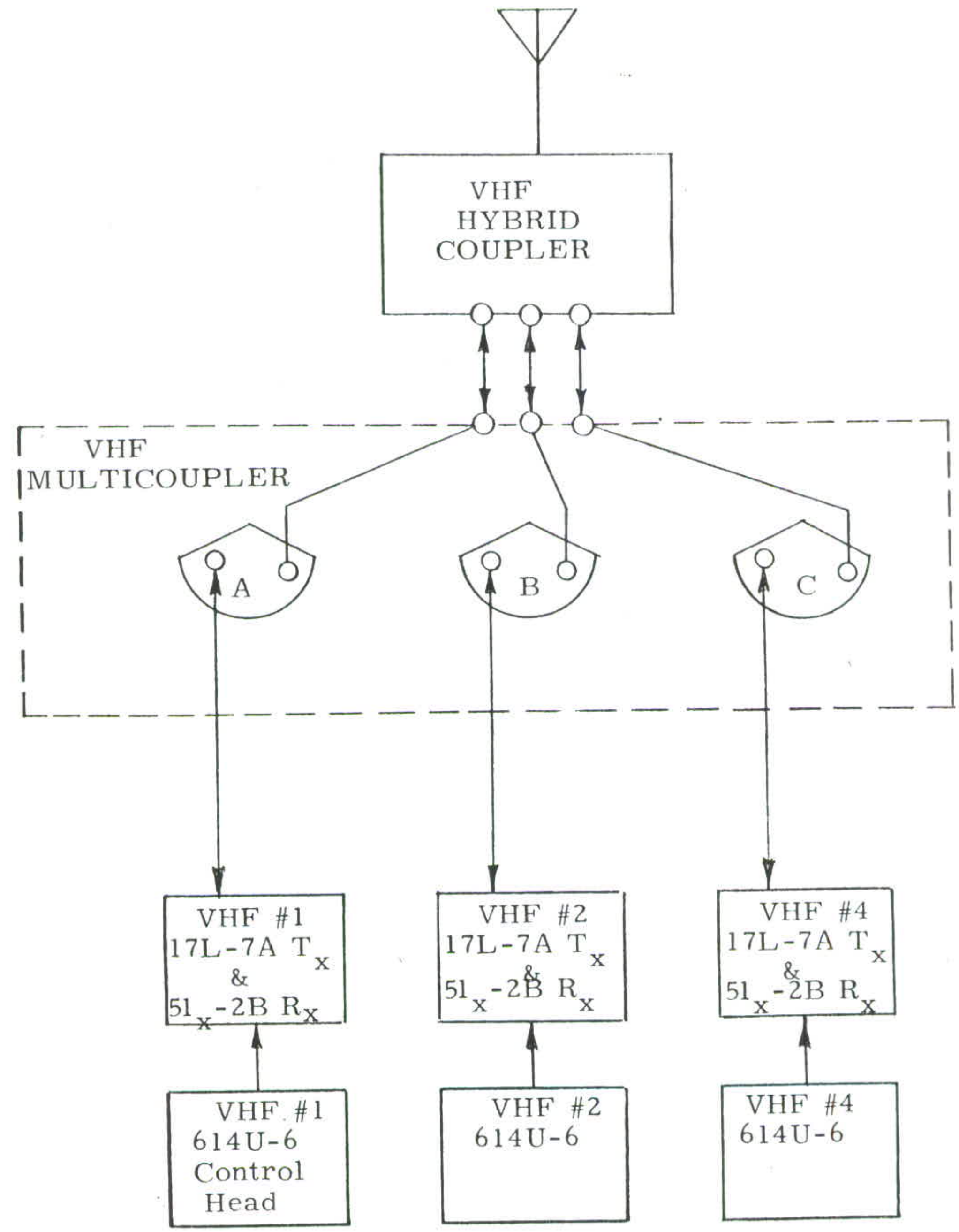


FIGURE 17: Recommended Method of Providing Additional Isolation by the Addition of VHF Hybrid Coupler to Operate in Conjunction with VHF Multicoupler.

conjunction with the VHF multicoupler. Instead of combining the cavity outputs at the multicoupler, each cavity must be provided with a separate output connector. The three signals are then combined in the hybrid coupler for application to the VHF antenna. The result is approximately 30 db additional isolation between the receiver-transmitters coupled to the same antenna.

c. Losses in Hybrid Coupler

The only difficulty that may be encountered by utilizing hybrid couplers is the approximate 6 db power loss (with four input type) for both transmission and reception. It is felt that the 6 db loss can be tolerated without seriously affecting air/ground/air communications within the aircraft control area for which the AN/TSQ-47 was designed. However, it may be worthwhile to conduct experiments with the present equipment by employing 6 db attenuators for transmission and reception to determine if air/ground/air communications are seriously affected.

A coaxial patch panel could be provided to enable patching around the hybrid coupler to the antenna when desired. This would require that the multicoupler make provisions for the options of combining or not combining the outputs of the cavities.

SECTION 9

Improvement of Accessibility and Utilization Capability of RACEP by Adapting for Operation With Dial Telephone Equipment

1. General

Since RACEP is a full duplex communications system, there seems to be room for considerable improvement over the present system by adapting future RACEP equipment for operation in conjunction with dial telephone equipment. With a suitable adapter, RACEP could be operated with standard military or commercial dial telephone equipment. With this equipment at all RACEP stations, the dial operation could be made fully automatic with no difference from standard dial telephone operation. The feature would also allow access to the RACEP from any dial telephone that wished to be connected. For instance, a RACEP could be placed at a base telephone center and would provide access to other RACEP stations from any dial telephone on the base.

2. Operation With Dial Equipment at Both Ends

Figure 18 is a basic block diagram showing dial telephone connection by way of RACEP. The RACEP Dial Adapter would provide all functions necessary to enable dial operation in conjunction with RACEP.

a. Calling Station

At the calling station the RACEP Dial Adapter functions would include:

(1) Sensing that calling party is connected to line.

(2) Providing dial tone to indicate to calling party that equipment is connected.

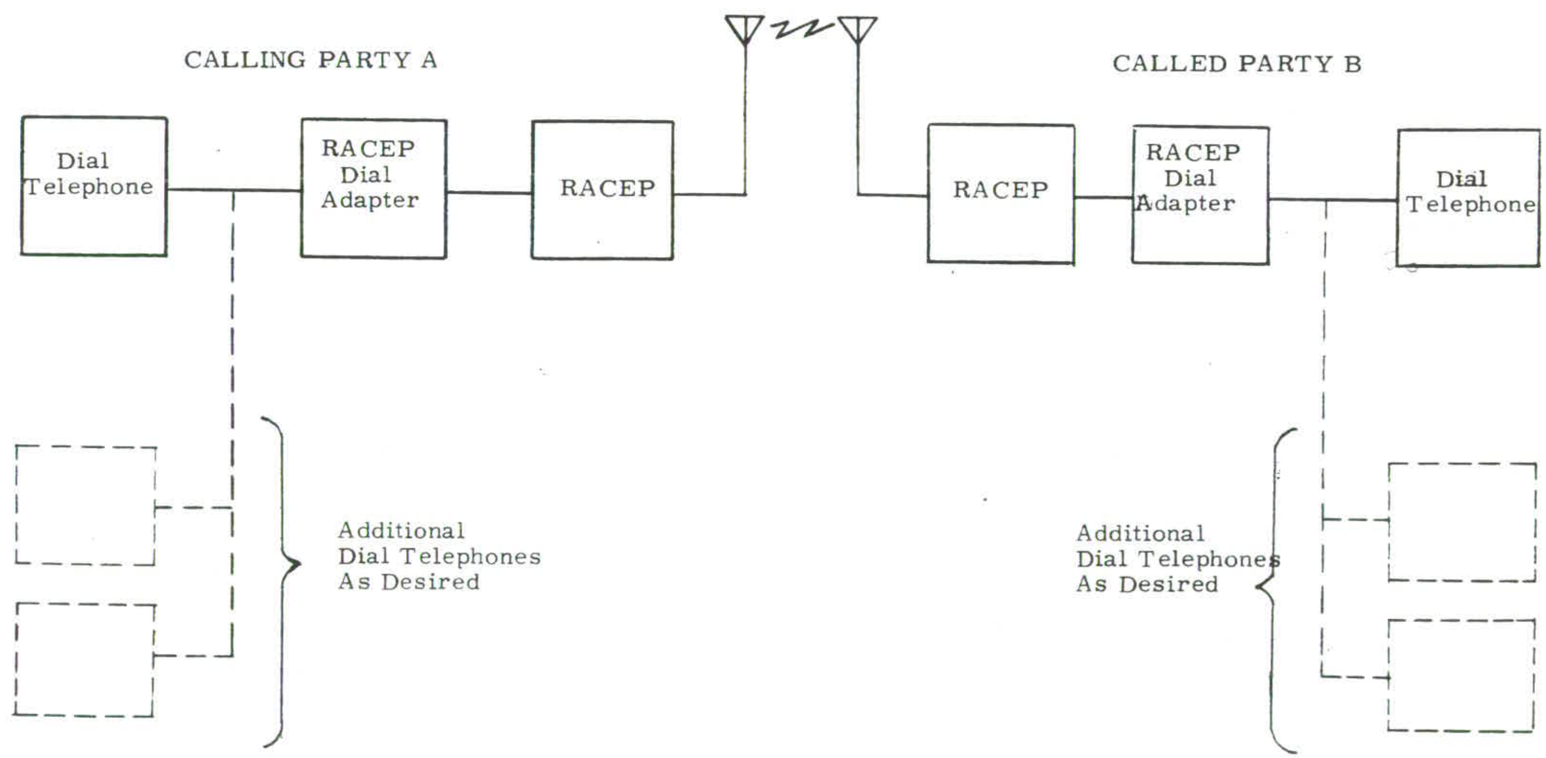


FIGURE 18: Block Diagram Showing Dial Telephone Operation Via RACEP with Dial Equipment at Both Ends

(3) Storing dial pulses and converting these to called station address. First digit of dialed number would indicate type of installation at opposite end; RACEP/Dial or RACEP alone.

(4) Monitoring calling station address and called station address to determine if busy.

(5) Sending busy signal to calling party if either channel is busy.

(6) Initiation of call if channels not busy.

(7) Transmission of pulsed tone giving calling station address to called station.

(8) Repeat "7" while monitoring calling station address until tone is heard from called station. Stop sequence when tone is received.

(9) Provide audible feedback to calling party indicating status of call. Disconnect this function when tone is received from called station.

(10) Provide duplex communications with called station from calling party telephone.

(11) Restore equipment to normal when calling party hangs up.

b. Called Station

(1) Monitoring the called station channel (address).

(2) Receiving pulsed tone and storing address of calling station.

(3) Setting up address of calling station for return transmission.

(4) Transmission of a short continuous tone to calling station each time called station receives pulsed tone address sequence.

(5) Initiate 20 cps ringing signal to called party telephone each time called station receives pulsed tone address sequence.

(6) Stop ringing signal when called party answers.

(7) Provide duplex communications with calling station from called party telephone.

(8) Restore equipment to normal when called party hangs up.

In the preceding discussion, since both ends are identical, it makes no difference which end is the calling party.

3. Operation With Dial Equipment At Only One End

At certain installations, it may not be advisable to provide dialing facilities for reasons of economy and due to a lack of requirement for the added flexibility. This condition would occur where only one operator normally requires access to the RACEP. In this case the installation would consist of the RACEP equipment alone. The RACEP Dial Adapter must also be compatible with this type of installation. A block diagram of the situation is shown in Figure 19.

Since the equipment at both ends is not the same, conditions will depend upon which end is the calling party. In condition 1, the calling party is assumed to be party A (dial telephone end). In condition 2, the calling party is assumed to be Party B (RACEP only, without dial facilities).

a. Condition 1: call originating at dial telephone end.

(1) Calling Station

At the calling (dial telephone) end the functions would include:

(a) through (f); same as those listed under paragraph 2.a., (1) through (6).

(g) Transmission of short tone followed by voice recording giving address of calling station.

(h) through (k); same as those listed under paragraph 2.a., (8) through (11)

(2) Called Station

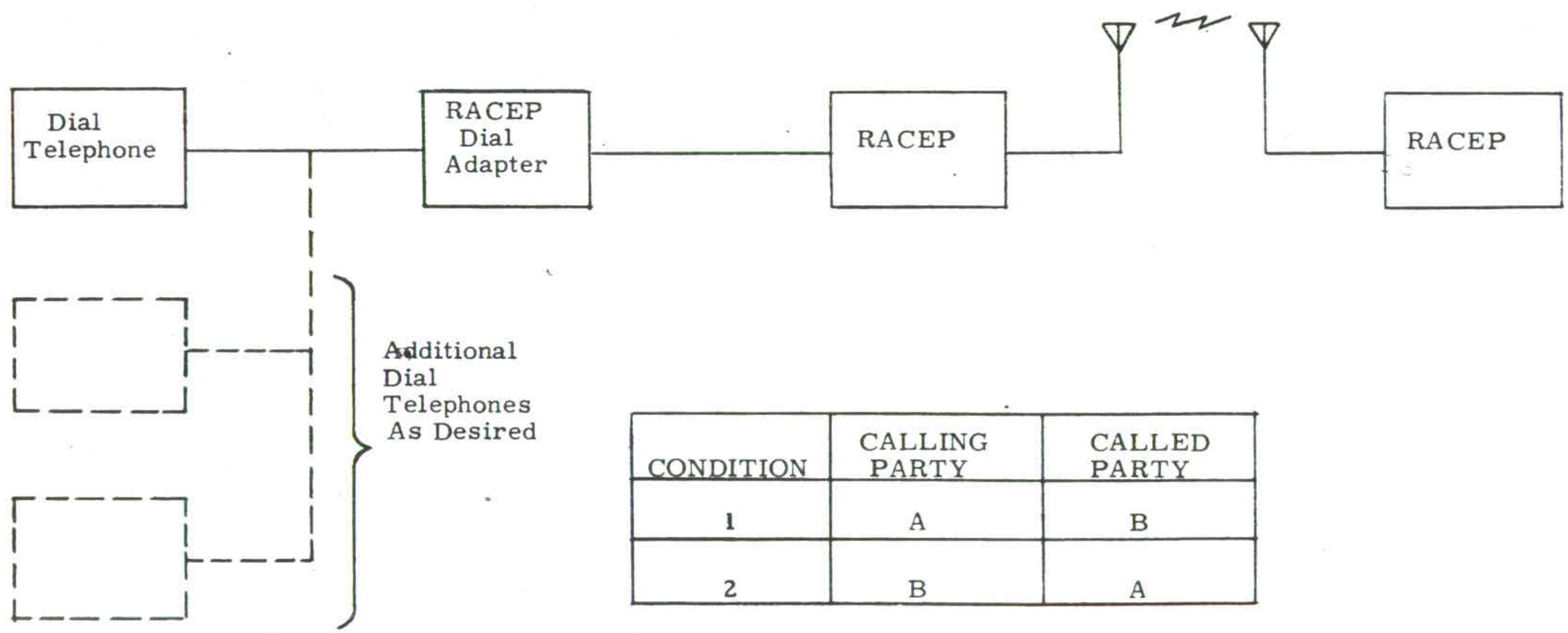
At the called (RACEP only) end the functions would include:

(a) Operator hears call tone and voice recording giving address of calling station.

(b) Operator sets up address of calling station for return transmission.

(c) Transmission of short tone (normal ring) by operator.

(d) Operator now conducts duplex voice communications with party on dial telephone at opposite end.



CONDITION	CALLING PARTY	CALLED PARTY
1	A	B
2	B	A

FIGURE 19: Block Diagram Showing Dial Telephone Operation Via RACEP with Dial Equipment at One End

b. Condition 2: call originating at RACEP only end.

(1) Calling Station

At the calling (RACEP only) end the functions would include:

(a) Operator selects address of station to be called.

(b) Operator monitors called station channel to determine if busy.

(c) Transmission of short tone (normal ring) by operator.

(d) Announcement of calling station address into RACEP microphone by operator.

(e) Repeat c and d until called party answers telephone at opposite end.

(f) Duplex communications available to telephone at opposite end.

(2) Called Station

At the called (dial telephone) end, the functions would include:

(a) Provision of a 20 cps ringing signal to the telephone when a tone (normal ring) is received at the called station. Set up equipment for dialing of calling station.

(b) Ringing signal inhibited when operator causes telephone handset to be connected to circuit.

(c) Provision of dial tone (tone could be of different frequency from normal dial tone) to indicate to operator that duplex connection is not complete because call is not coming from dial system.

(d) Operator dials first digit which would be a code for indicating to the RACEP Dial Adapter that call is going to a non-dial facility.

(e) After dialing first digit, dial tone stops and operator listens for address of calling station

(f) When operator receives address of calling station (by voice from operator at opposite end), this is dialed into RACEP/ Dial Adapter.

(g) RACEP is set to calling station address.

(h) Duplex telephone communications is now available to calling station.

(i) Equipment is restored to normal when called party hangs up.

4. Modifications of RACEP Which Would Improve Performance When Operating in Conjunction With Dial Telephone System

The preceding discussion has assumed that little or no modifications would be made on the present RACEP equipment and that all new functions would be handled by the RACEP Dial Adapter. However, with a few modifications to the RACEP the dial operation could be made more automatic and foolproof. Some of the possible modifications are as follows:

a. RACEP Station Selector

The station selector is used for selecting the address of the station on the opposite end of the communications circuit. In order to operate with dial equipment, the station selector must be operated electrically. In the present RACEP configuration, this would call for a motor driven device or devices, to be attached in place of the station selector knobs. This device would be electrically connected to the RACEP Dial Adapter and would select a station address according to signals from the adapter.

If the RACEP equipment were modified to directly accept electrical control of address selection, considerable simplification would result. A cable connector could be provided for making connections to the dial adapter and a REMOTE/LOCAL switch could be provided to enable local manual selection or remote electrical selection of station address.

b. Normal ring signal

The NORMAL RING button causes a tone to be transmitted to the distant station where it is heard as an audible output from the speaker

and also causes the CALL lamp to be illuminated.

It is recommended that the ring signal be modified in a manner that will enable it to transmit the address of the station from which it originates. This could be done by utilizing a pulsed or fsk tone to transmit the station address. If this modification was accomplished, the RACEP Dial Adapter could be simplified and operation could be made more automatic; for instance, the functions in paragraph 3b (1) (d) and paragraph 3b (2) (c) through (f) could be eliminated.

c. Automatic Set-Up of Calling Station Address

With the present RACEP, the caller must identify the calling station's address by voice and the called station must set up this address for transmission. In conjunction with the modification recommended in b preceding, a further modification could be made which would eliminate this procedure. Since the ring signal would identify the calling station, the RACEP could be modified to automatically set this address into the equipment at the called station. The operator would merely have to answer the call.

This modification of the RACEP would enable the RACEP Dial Adapter to be simplified still further.

d. Improved method of determining whether channel is busy.

In order to determine if a given channel (address) is busy, the present RACEP requires that the operator listen on the called station address before transmitting. Unfortunately, this is not an exact method of determining if the channel is busy. Since RACEP provides for duplex operation with independent channels in each direction, the condition could be such that although nothing is heard on the channel (address) being monitored, the channel is busy because, at the moment, the party being monitored is listening on his receive channel rather than talking on his transmit channel. To positively determine that a channel

is not busy could be time consuming.

To overcome the preceding difficulty, it is recommended that the present RACEP be modified to provide an option of transmitting continuously when in communication with another station. (The present RACEP transmits only when a voice input is present at the microphone). At the receiving end, the RACEP equipment could be modified to determine almost instantaneously when a channel was busy provided the transmission from the opposite station was present. As an added feature, a lamp could be provided to illuminate and give a visual warning when the channel was busy. This feature would further decrease the complexity of the RACEP Dial Adapter.

SECTION 10

Recommendations for Improvement of the Microwave Subsystem

1. General

The majority of recommendations for improvement of the microwave subsystem have been included in a previous report (ESD-TDR-64-199) concerned with electromagnetic interference problems and interface problems. Additional recommendations for improvements not related to interference and interface are included in the following paragraphs.

2. Protection of Klystron Tubes in Microwave Transmitters and Receivers

When the microwave equipment is initially turned on, the sequence must be such that the klystron filaments are allowed to warm up for approximately 5 minutes before the klystron beams are turned on at each receiver and transmitter. This prevents damaging of the klystrons. If primary power is interrupted (due to generator failure, etc.) and then restored without placing the BEAM switches to the OFF position, damage to the klystrons can result.

To overcome the preceding problem, the transmitters and receivers should be modified to include automatic cycling of the klystron beam turn-on function. In other words, the beams should be automatically turned on approximately 5 minutes after filament voltage is applied, and in the event of a primary power failure the timer should be immediately reset to repeat the five minute delay, or provide a delay proportional to the amount of time (within limits) that the power was "OFF".

3. Improvement of Reliability of IFR-PAR Microwave Link

Transmission of radar data from the precision approach radar (PAR)

to the control center (IFR) requires two separate microwave channels. If either of these channels fails, the radar data from the other channel is completely useless. In order to improve the reliability of the IFR-PAR microwave link, it appears that absolute dependence on a given microwave channel should be eliminated. This can be accomplished by the addition of a spare (third) microwave channel transmitting from the PAR shelter to the IFR shelter. This will require the addition of a microwave transmitter at the PAR terminal and a microwave receiver at the IFR-PAR terminal.

To accomplish this modification will require more than the addition of the microwave receiver and transmitter. At both (IFR and PAR) terminals, each rf power supply is working at capacity since it is already supplying three rf units (receivers and transmitters). Another rf unit cannot be added to the power supply load without removing one of the units that was previously connected. Fortunately, this approach will be satisfactory in this case since the spare unit will replace a faulty unit that was previously connected.

When the spare equipment is added, there will be three microwave transmitters at the PAR terminal and three microwave receivers at the IFR-PAR terminal. At each terminal, two of the units should be operating and one should be on standby (power applied to tube filaments and cavity heaters). There will be no difficulty in keeping the third unit on standby since this only requires 400 cps primary power and does not affect the rf power supply. In order to enable selection of any one of the three units for standby and the other two for operate, a selector switch will be required for appropriate switching of the dc voltages from the rf power supply. Indicator lamps should be provided to operate in conjunction with the selector switch and indicate the status (STANDBY or OPERATE) of the rf units. When rf units are switched from standby

to operate and vice versa, it is also necessary to transfer the video signals accordingly. This can be accomplished very easily since the present microwave terminals are equipped with video patch panels that can handle six video channels, only three of which are presently used.

There should be no difficulty in adding a third microwave transmitter at the PAR terminal since space is available in the racks, although rearrangement of the equipment within the racks may be required. At the IFR-PAR terminal, however, it is doubtful if enough space is available in the racks to enable the addition of a microwave receiver, regardless of how the equipment within the racks is rearranged. In order to provide enough space in the racks, it is proposed that the order wire unit be removed from its rack and be placed at some other convenient location within the shelter. This would not be difficult to accomplish since the order wire is a self-contained unit requiring only 400 cps primary power and the necessary signal leads.

4. Elimination of Dependence on Microwave Equipment When Utilizing Cable Link Between Search Radar and Control Center

Under the present method of operation when sending radar data from the search radar to the control center via cable, it is necessary to utilize a portion of the microwave equipment in order to transfer the azimuth data from the search radar antenna. This is necessary because the azimuth data is obtained in the form of resolver signals and must be converted to synchro signals at the control center in order to be compatible with the search indicators and the track-symbol group.

Figure 20 shows the present method employed for transferring the search radar azimuth data via cable to the control center. It should be noted that the equipment required includes a reference generator and associated power supply at the search radar, and an electronic

control amplifier, synchro assembly and associated power supply at the control center.

Figure 21 shows the recommended method of transferring the search radar azimuth data via cable. It should be noted that the requirement for the reference generator, electronic control amplifier, synchro assembly, and associated power supplies has been eliminated. This is accomplished by employing a direct synchro system rather than a resolver to synchro conversion.

The recommended azimuth data system requires the addition of one and ten speed synchros to the shafts in the radar pedestal which drive the one and ten speed resolvers, respectively. In addition, the synchros require twisted shielded triples rather than twisted shielded pairs in the interconnecting cable between the search radar and the control center. Also, the reference signal originates at the control center rather than at the search radar. There is no present requirement for the 10 speed synchro; however, it is felt that this should be included for possible future applications.

It should be noted that the resolver servo system utilizes phase comparison for error detection, whereas the synchro servo system utilizes amplitude comparison. Phase comparison should be more accurate under conditions of noise, interference, and amplitude variations. In addition, the resolver system uses a reference signal which is separated in frequency (approximately 26 cps) from the 400 cps primary power. The synchro system uses the 400 cps primary power at the control center for reference. This reference must go to the search radar shelter where the 400 cps primary power for the shelter is obtained from a different generator which is not synchronized with the generator at the control center. The two frequencies will not be identical and if the synchro circuits are not adequately isolated from

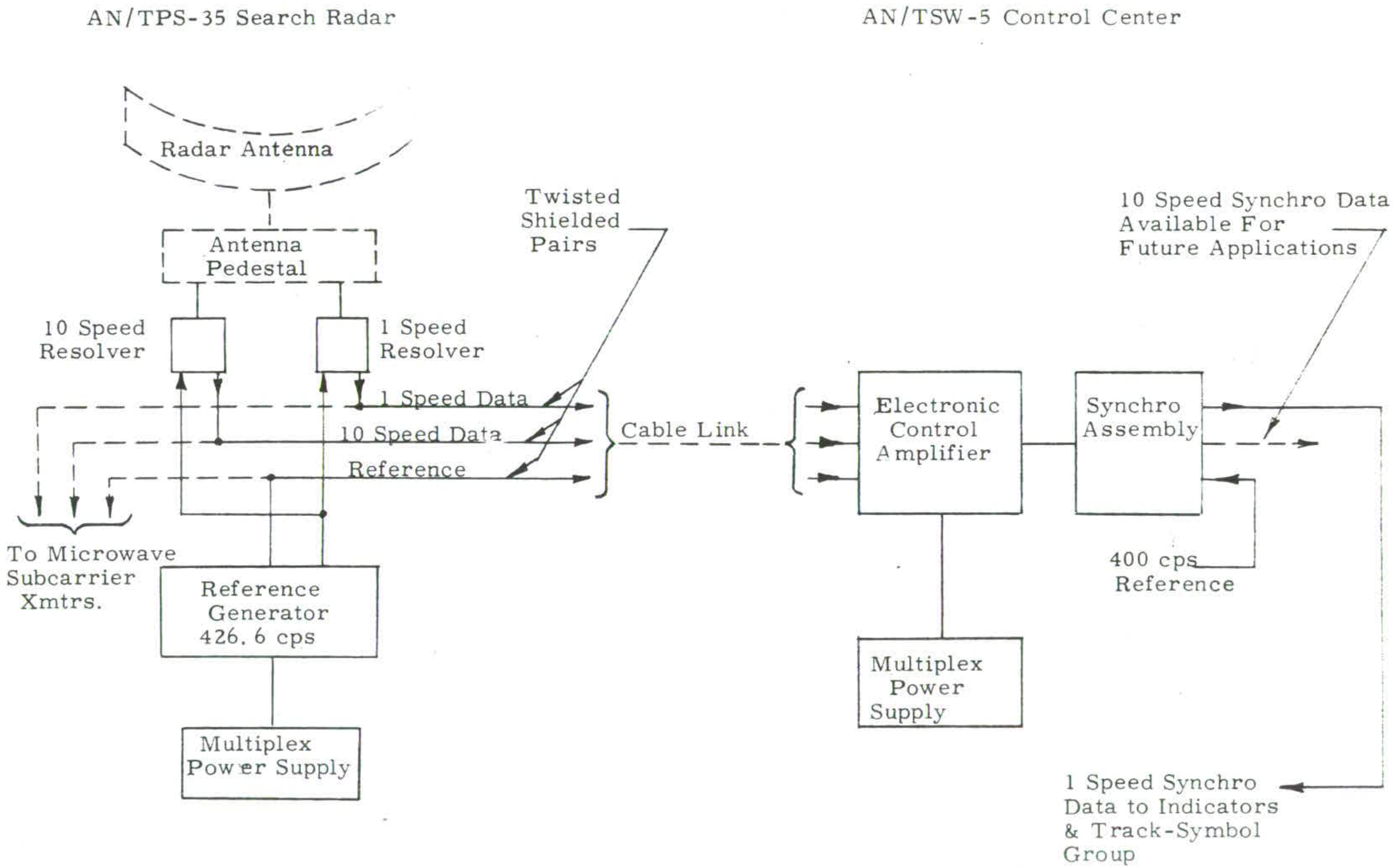


Figure 20. Present Method of Transferring Search Radar Azimuth Data Via Cable

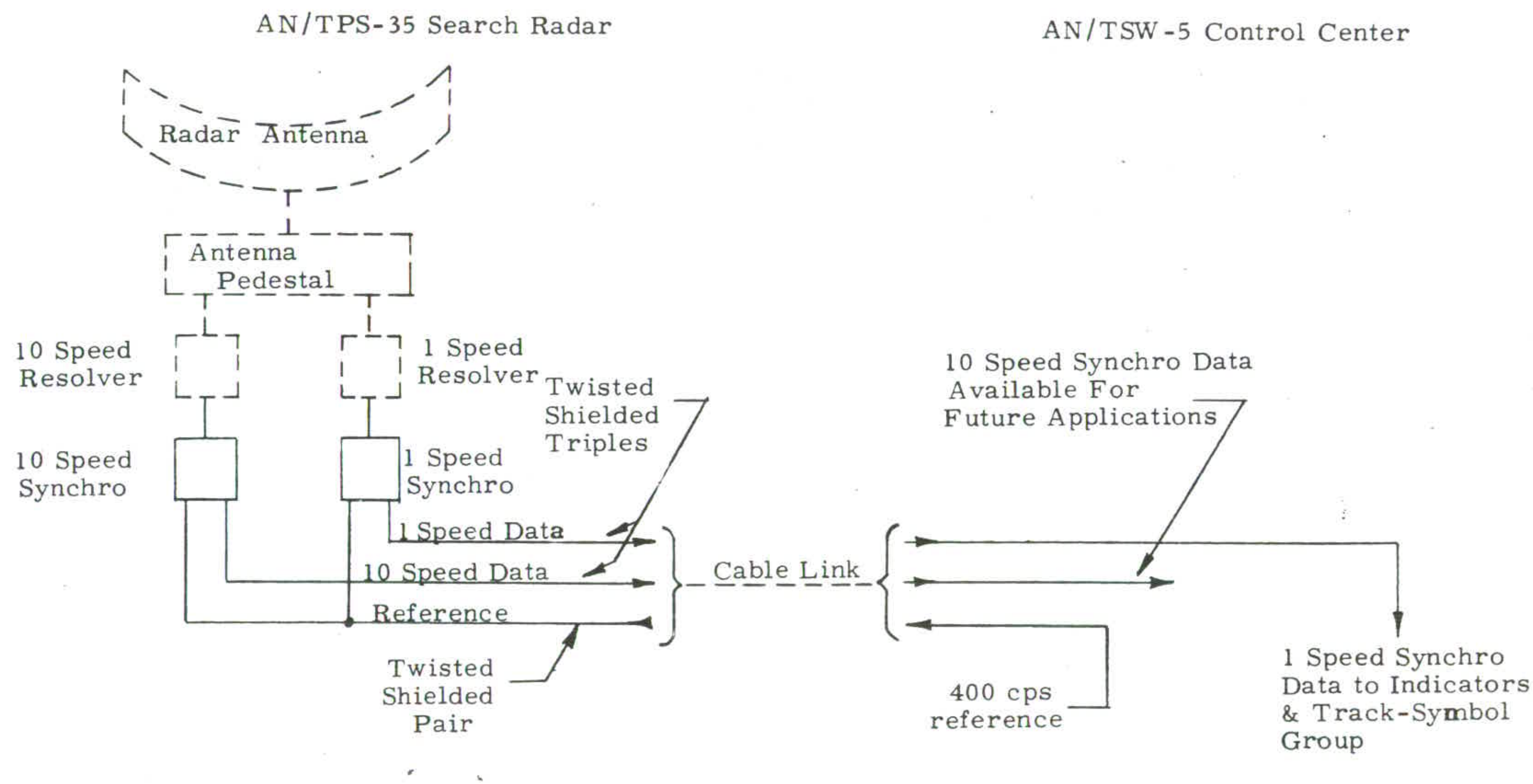


Figure 21. Recommended Method of Transferring Search Radar Azimuth Data Via Cable

the primary power, a heterodyning could result which would be slow enough to be within the response time of the servo system and could cause disturbing patterns and azimuth errors to occur at the search radar indicators.

In view of the preceding conditions, it is recommended that the proposed method of transferring azimuth data be tried out on an experimental basis before adapting it for use in future AN/TSQ-47 systems.

5. Improvement of Microwave Antenna Mounts

The AN/TSW-5 (IFR), AN/TPN-14, and AN/TPS-35 shelters require microwave antennas to be mounted either to the sidewall or roof. In the case of the AN/TSW-5, 4 ft-diameter and 2 ft-diameter antennas are roof mounted; the AN/TPN-14 carries a 2-ft diameter antenna on a mast mounted to the shelter side-wall, and the AN/TPS-35 shelter has a side-wall mounting arrangement which carries a 4 ft-diameter antenna.

It is estimated that the maximum distance between the AN/TSW-5 (IFR) and the AN/TPN-14 shelters (microwave link with two ft. diameter antennas at each end) will be 5 miles, and that between the AN/TSW-5 (IFR) and AN/TPS-35 shelters (microwave link with four ft. diameter antennas at each end) a maximum of 15 miles. Beamwidth for the 2 ft. diameter antenna is 5°, and for the 4 ft. diameter antenna, $2\text{-}1/2^{\circ}$ (on both vertical and horizontal axes). A drop in power of 1 db is estimated to accrue with a 4-foot antenna misalignment of 1/2 degree, or a 2-foot antenna misalignment of 1 degree. Misalignment of both 4-foot or 2-foot antennas would, of course, be additive insofar as power loss is concerned.

Misalignment can be caused by reasons other than poor initial set-up. Subsidence of the shelter to which the antenna is mounted could cause very sizeable line-of-sight deviations. By way of example on the

AN/TSW-5; if the jack pads at one end of the long dimension of the shelter (180 inches) were to sink into the ground 1-1/2 inches, while those at the other end did not, and the antennas were oriented in a direction roughly parallel to the long dimension, the resulting line-of-sight deviation would be approximately 1/2 degrees.

A second cause of misalignment is static deflection of the antenna structure due to snow and ice loading.

The cause of misalignment most suspect, however, is deflection of the structure due to wind loads on the antenna. Calculations were made to determine structural deflections and attendant stresses for the several mounting arrangements. This was done by RCA engineers and also by the vendor, and there was general concurrence that deflections due to wind loading did not exceed 1/2 degree in elevation or in azimuth, and that stresses were not prohibitive.

In the course of the rigidity and strength investigation, some suggestions were made concerning improvement of the structure supporting the antennas as well as the technique of azimuth and elevation adjustments. It is believed that circular pipe (as used for support of the 2 ft. diameter antenna on the AN/TPN-14) and strap (used on the supporting structure for the 4 ft. diameter antenna on the AN/TPS-35) are rather poor in bending, and perhaps additional rigidity could have been obtained, with less weight, by utilizing other structural members having a greater cross-sectional moment of inertia.

The coarse and fine adjustments for antenna alignment both in azimuth and elevation should perhaps be redesigned, and suggestions were made in this connection during the course of the project. One particular feature is the tendency of the upper clamp (4 ft. diameter antenna, AN/TPS-35 and AN/TSW-5) to lock against the vertical pipe,

due to the cantilevered weight of the antenna assembly, making coarse azimuth adjustment rather difficult. If both upper and lower clamps were made into a single rigid assembly plus struts running to the antenna elevation trunnion brackets the condition might be relieved.

Some questions also arose during the course of the project regarding the split-clamp type of brackets to lock the 2 ft. antenna structure to the pipes. The clamps were fabricated from flat stock and tended to deflect as the clamping screws were tightened. The dependability of this type of friction clamping is questionable, not only due to the inefficiency of the clamp, but the fact that clamping after alignment has been effected could cause the structure to become misaligned due to the split clamp deflections.

6. Recommendations for Microwave Tower Assembly

In order to establish communications via microwave link between shelters in the AN/TSQ-47 system when no direct line-of-sight path exists between the standard shelter mounted antennas, a microwave tower assembly will be required. Detailed recommendations concerning the required microwave tower assembly are contained in Technical Documentary Report No. ESD-TDR-63-601, Appendix II.

7. Methods for Location of Remote Microwave Terminals by Radar and Radio

a. General

The precision approach radar and the search radar of the AN/TSQ-47 are remotely located from the control center and information is transmitted via microwave. When the AN/TSQ-47 is deployed in the field, the position of the radars relative to the control center may be difficult to determine because of terrain, inaccurate maps and lack of visibility caused by darkness, rain, snow, or fog. These problems could cause considerable delay in the

establishment of the microwave links since the azimuth of the opposite terminal must be accurately known in order to accomplish alignment of the microwave antennas as rapidly as possible.

The following paragraphs describe methods of determining, by radar or radio, the direction to the opposite microwave terminal. Once this is established, the personnel at the opposite terminal can also be informed of the magnetic bearing to use in aligning their microwave antenna.

b. Location by Utilization of Radar

Either of the two radars could be utilized to locate the control center provided there was a method of discriminating between the sites and local ground clutter. It is proposed that the control center be equipped with oscillators or signal generators which would radiate at the frequency of the PAR (X band) and the search radar (L band). These units should be small and portable, operate from 400 cps power, have self contained antennas, and provide adequate power to enable the radar to easily distinguish the transmission from clutter. Since the control center may sometimes be located below the level of the main radar beam, the power should be sufficient to overcome this difficulty. The power level should be controllable in order to prevent saturation of the radar receiver and allow accurate determination of the direction of the source of radiation. Frequency stability should be such that when the oscillator is calibrated with its respective radar at a depot, operation will be satisfactory when deployed in the field.

When the search radar is employed for this function, the general direction of the signal can be rapidly located during normal search; and then by manual positioning of the antenna, a more accurate fix can be obtained.

When the PAR is employed for location of the control center, the azimuth scan antenna should be centered toward the assumed direction of the control center and then be caused to scan through a 60 degree sector. Once the general direction to the control center has been established, the azimuth scan can be changed to 30 degrees for a more accurate determination of the direction of the control center.

c. Location by Utilization of UHF Communications

Since both radars and the control center contain at least one ARC-52 UHF communications transceiver, a radio direction finder located at the control center could be employed to determine the azimuth (and possibly elevation) of each of the radar sites.

For determining the direction of UHF radio signals the AN/GRD-11 UHF doppler direction finder would be the most satisfactory since it can determine the azimuth to an accuracy of $\pm$ 1 degree within a tenth of a second. Unfortunately, this equipment is not installed in the AN/TSW-5. The next best solution appears to be to provide the necessary additional equipment to operate in conjunction with the ARC-52 as a radio direction finder. The direction finding would normally be accomplished at the AN/TSW-5 so that only one set of equipment would be required for both microwave links.

This equipment would consist essentially of a manually controlled antenna with a pattern suitable for sensing the direction of the received UHF signal, a voltmeter for measuring the ARC-52 AGC voltage to determine when the antenna was properly positioned, and an adjustable attenuator for controlling the RF signal level to the ARC-52 receiver in order to operate on the most sensitive portion of the AGC curve. The antenna should be as light as possible and an inflatable helical antenna or an Adcock array is recommended. In using the helical antenna, the

antenna would be manipulated for maximum meter indication (maximum signal). The Adcock array would be manipulated for a null(minimum signal). The Adcock antenna has two null positions separated by 180 degrees; however, this problem should be easily resolved since the direction to either radar site should be known to within 180 degrees. If no reflections are present, either of the antennas should be able to determine the radio direction to within approximately $\pm$ 5 degrees. The Adcock antenna would probably be more accurate since the null is sharper than the main lobe of the helical antenna.

Additional accessories required with the antenna are: a compass, manual antenna mount, portable tripod, and a set of cables for connecting the antenna and voltmeter to the ARC-52 receiver. All items are more fully described in Table 3.

The total weight of the direction finding equipment, exclusive of the ARC-52 would be approximately 55 pounds.

TABLE 3: EQUIPMENT REQUIRED FOR UTILIZING ARC-52 AS UHF DIRECTION FINDER

Item No.	Name	Description and Remarks	Approx. Weight (lbs.)
1-A	Bifilar Helical Antenna	a. Comparable to Andrew Type 53000-2N b. Inflatable antenna c. Length (inflated portion), approx. 6 ft.; dia., approx. 18 inches d. Desirable beamwidth of less than 35 degrees. e. Frequency range, 350 to 400 mc.	10
1-B	Adcock Array	Designed for frequency of around 390 mc.	less than 10
2.	Manual antenna mount	Comparable to Andrew Type 51930A	9
3.	Portable tripod	Comparable to Andrew Type 519355A	12
4.	Voltmeter	Sensitive enough to measure ARC-52 AGC voltage (with negligible loading) and give not less than 1/2 scale deflection on most sensitive portion (max. slope) of AGC curve.	2
5.	Attenuator	Adjustable to within 1 db with range of attenuation sufficient to reduce AGC voltage to optimum working level when transmitter is separated from receiver by not more than 500 yards. Suggested range 0 to 100 db. Frequency range, 350 to 400 mc.	2
6.	Magnetic Compass	Marine type; readable to 1/2 degree. Mounted on gimbals to maintain horizontal position when housing is tilted up to 45 degrees. Attached to manual antenna mount.	2
7.	Coaxial Cable	Type RG-52C or equivalent for connecting antenna, via attenuator, to ARC-52 receiver. Of sufficient length to run from antenna on roof of comm. annex shelter to ARC-52 antenna connector on shelter wall. Approx. 15 ft. should be sufficient.	5
8.	Single conductor Shielded Cable	For connecting voltmeter to main AGC of ARC-52 receiver. Approx. 25 ft. should be sufficient.	3
9.	Transit Case	For storing equipment	10
		TOTAL WEIGHT	55

SECTION 11

Recommendations for Improvement of AN/TVN-1 Lighting System

1. General

The AN/TVN-1 is an air-transportable airfield lighting system which can be deployed in support of worldwide air operations wherever fixed facilities are not available. Although not a part of the AN/TSQ-47, the AN/TVN-1 is designed to operate in conjunction with the AN/TSQ-47, and improvements in the AN/TVN-1 will contribute, indirectly, to improved capability of the AN/TSQ-47.

2. Reduction in Equipment and Weight by Changing to DC Lighting System

The present AN/TVN-1 provides 60 cycle power for the lights from a 60 cps constant current regulator. This 60 cycle power is obtained by utilizing a solid state converter to change from 400 cycles, provided by the gas turbine generator, to 60 cycles. Each lamp is connected through an individual transformer to the constant current (series connected) power distribution circuit. The series connections reduce power losses in interconnecting cabling and the transformers prevent the failure of one lamp from interrupting power to the whole chain. Utilization of 60 cycle power for the lights was necessary because of inductance and capacitance problems that could be encountered with 400 cycle power.

Direct current was previously considered for supplying the lights; however, since the lights are connected in series to reduce power loss in the interconnecting cables, there was no reliable method available for automatically sensing the burnout of an individual lamp filament and causing a short to be connected across the lamp terminals to prevent interruption of the power to all lamps in the circuit. In addition to this,

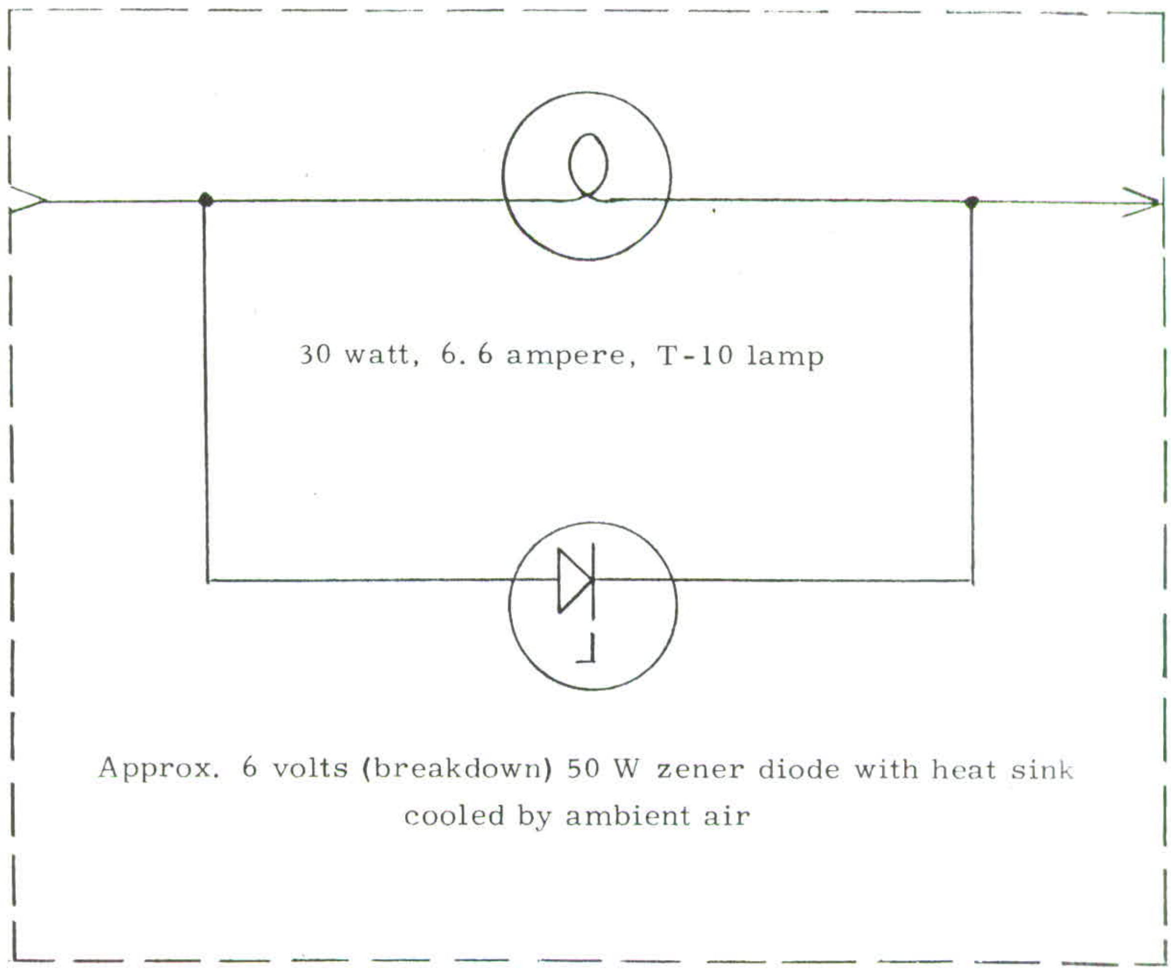
there was the possibility of arcing within the lamp which would make it even more difficult to determine an open circuit condition.

By employing a new approach, it now seems possible to design a DC lighting system which will avoid the preceding difficulties. This could result in considerable savings in weight and cost by elimination of the 400 to 60 cps static converters, the transformers for each lamp, and reduction in size of the constant current regulator.

a. Approach for Solving Lamp Burnout Problem

In order to solve the problem of lamp burnout in the DC lighting system, it is recommended that a zener diode be employed across each lamp to conduct current in the event the lamp fails. The zener diode would have a breakdown voltage slightly higher than the highest recommended operating voltage of the lamp. As long as the lamp filament remained intact or did not increase appreciably in resistance, the voltage drop across the lamp resulting from the constant DC current supply would be below the zener breakdown voltage. If the filament opened up, the breakdown voltage of the zener diode would be exceeded and the current path would be maintained through the diode. If the filament increased in resistance to the point where the zener breakdown was exceeded, a portion of the current would be conducted by the diode. Since the voltage across the lamp terminals could never rise more than a small percentage above the recommended lamp voltage, difficulties from arcing should be eliminated. A schematic diagram of the lamp circuit and associated zener diode shunt is shown in Figure 22.

It may be possible to incorporate the zener diode in the lamp holder and utilize the metal portion as a heat sink for the diode. The zener diode must operate above electrical ground and this means that the diode must be insulated from the heat sink. The voltage level of the



LAMP ASSEMBLY

FIGURE 22: Schematic, DC Lamp Circuit with Zener Diode Shunt

diode relative to ground could be as much as 1000 volts, depending upon the lamp position in the series string and the number of lamps in the string. Insulation of the diode from the heat sink should not create much more difficulty than is presently encountered in insulating the transformer and lamp from the ground. The primary requirement for the diode is an insulator with good thermal conductivity.

b. Advantages Resulting From Elimination of Lamp Transformers

Utilization of the zener diode should result in considerable weight saving since it would take the place of a transformer weighing approximately 10 pounds. It is doubtful if the weight of the diode and heat sink would exceed 1 pound in any circumstances. The result would be a weight saving of 9 pounds per lamp installation. Since the AN/TVN-1 has a total of 138 lamps, the net weight reduction by elimination of the lamp transformers should be more than 1000 pounds.

c. Advantages Resulting From Elimination of Static Converter

By utilizing a DC lighting system, the two 400 cps to 60 cps static converters will no longer be needed. Elimination of the static converters will result in a reduction in weight and an improvement in reliability of the AN/TVN-1. Since each static converter weighs 393 pounds, the total weight reduction will be 786 pounds. This does not include the associated cabling for the static converters which will no longer be needed. Elimination of the static converters will also result in improved reliability of the AN/TVN-1 because of the reduction in components. Needless to say, a reduction in cost will also accrue from the elimination of the static converters.

d. Advantages Resulting From Change to DC Constant current Regulator

Since the present AN/TVN-1 employs a 60 cps constant current regulator, a considerable weight reduction should be attained, for equal

power output, by utilizing a DC constant current regulator which operates directly from 400 cps input. The constant current regulator should be an integral unit containing a 400 cps 3 phase step-up transformer with solid state silicon controlled rectifiers to regulate the current.

The present AN/TVN-1 is provided with two 4 KW, 60 cps, constant current regulators. Both of these units operate at full capacity and no spare is available in the event of a failure. Failure of the constant current regulator will result in loss of approximately 50% of the airfield lighting. It is recommended that the DC constant current regulator be designed to provide an output of 4 KW. This new regulator would be smaller in size and weight than the present 4 KW unit. Three of these DC regulators could be provided and should require no more space than two of the present type. The third would be available as a spare for emergencies. Automatic switchover could be employed if desired.

Another advantage of using a DC lighting system results from the more efficient use of the interconnecting cabling to the lights. For a given cable insulation and wire size, more lights can be employed in a given series string when using AC. This is true because the cable insulation must be adequate to handle the peak value of the AC voltage (1.414 times the rms or effective value), while the peak and effective values of the DC voltage are the same and may (theoretically) be operated at the same level as the peak AC voltage. Unfortunately, the DC level cannot be set at the theoretical maximum allowable for the cable insulation because of the slight voltage increase resulting from a lamp failure.

3. Changes Required to Make Runway End Identifiers Compatible With DC Lighting System

The present runway end identifier lights will not operate from the

60 cps constant current source. To operate with the DC lighting system, a modification will be required to enable conversion of the constant current DC to a high voltage for operation of the lights. This should be capable of being accomplished fairly easily by means of a small solid state converter.

4. Reduction in Weight of Lamps and Accessories By Utilizing Quartz Lamps

Each runway or taxiway light for the AN/TVN-1 includes the lamp, lens, basic fixture (consisting of lens hold down spring, housing assembly, cone, cone support springs, and mounting column), breakable coupling, and mounting stake. A reduction in the size of the lamp should allow a corresponding reduction in the size of the accessories except perhaps for the cone.

It is recommended that serious consideration be given to the utilization of a miniature quartz lamp and the design and development of corresponding compatible accessories. One type of lamp which may prove satisfactory is the General Electric No. 1962 miniature quartz lamp. The total length of this lamp is approximately 1 inch including the mounting base, and the diameter of the quartz bulb is approximately 1/2 inch. Additional characteristics of this lamp are listed below:

Applied Voltage	Approx. Candlepower	Watts	Avg. Life (Hrs.)	Remarks
8.5	80	62	50	Design voltage
7.0	45	46	500	Reduced voltage for extended life
6.0	25	37	2500	Reduced voltage for extended life

Since the quartz bulb of the miniature lamp has high resistance to

thermal shock, it may be possible to manufacture the lens, required for runway lighting, as an integral part of the bulb. Since several lens colors are required, this would require that the bulbs be manufactured in several colors. With the integral lens bulb, there should be no problem with snow and ice accumulation since the exposed surface would have a fairly high temperature. Even if a separate lens was required for the lamp, the possible reduction in size and weight should be significant.

5. Additional Possibilities for Future Improvement of Transportable Airfield Lighting System

For the future improvement of the transportable airfield landing system, it is recommended that an investigation of the possibilities of utilizing fuel cells be considered. If a practical fuel cell could be obtained, each light could be packaged into a unit containing its individual fuel cell. A small transistorized radio receiver could also be contained in the package to allow remote control of the light. The lights could be placed on an airfield without need for interconnecting cabling to the constant current regulator. In fact, there would be no need for current regulators or generators or even the shelter as supplied with the AN/TVN-1. All lights could be controlled from the airport control tower by means of a small radio transmitter.

A practical fuel cell is considered to be one which could operate a light for several days on a small supply of aircraft type fuel. The size and weight of the fuel cell, without fuel and fuel container, should not be much greater than that of a 200 ft. section of cable that is presently used to interconnect the lights about the airfield.

SECTION 12

INTERROGATOR SET AN/TPX-28

1. General

It is always necessary to update equipment when there is a high degree of dependance on such equipment. Since the IFF/SIF interrogator unit RT-211 is in this category, it becomes necessary to recommend a newer and updated SIF/IFF interrogator system. During military operations it becomes an acute requirement to have a highly reliable IFF System. Since the design of the present RT-211 system is 8-10 years old, it becomes more obsolete each year of operation.

2. Interrogator Set AN/TPX-28

The recommended interrogator set consists of six plug in modules.

(1) Coder-synchronizer

(2) Oscillator-Driver

(3) Receiver

(4) Video Separator

(5) Power Supply Low Voltage

(6) Power Supply B+

The interrogator unit, to be compatible with the existing AN/TSQ-47 IFF system, requires only the Receiver/Transmitter unit, which would be installed in the AN/TPS-35 sub-system. The AN/TSW-5, at the present time, contains the coder synchronizer, video separator unit and a self contained power supply.

The TPX-28 interrogator measures 11 x 17 x 8.5 inches and weighs a total of 75 pounds.

3. Main Chassis

The Main Chassis provides the interconnections between the

modules as well as connections to external equipments and signals.

The blower is also located in the Main Chassis; a centrifugal blower is used, drawing air from under the chassis and blowing it into the lower part of the chassis which forms a plenum chamber. Orifices are provided into the various modules to achieve the cooling of the modules. The orifices serve to meter the air so that the modules dissipating the largest amounts of power receive the greatest volume of cooling air.

Also located on the Main Chassis are the time delay circuit for the high voltage and the duplexer for separating the received and transmitted signals.

4. Coder-Synchronizer

The Coder-Synchronizer is housed in a module 8" long by 4-1/2" high by 3" wide and is divided into eight submodules. All the trigger processing and coding required in the Interrogator is accomplished in the Coder-Synchronizer and all the codes generated are referenced to a crystal-controlled clock. The code is determined by the coder, the settings of the switches on the Control Box, and the mode gate generator; the actual pulse position is determined by the clock generators. Two modulator-driver circuits are used: the first accepts triggers from the SIF coder and generates suitable pulses for an SIF transmission; the second accepts triggers from an external source and generates suitable pulses for Mark XII transmission. Provisions are incorporated for self triggering in which the synchronizer produces independently the triggers for otherwise normal operation. Detailed operation of the various circuits and submodules of the Coder-Synchronizer is presented below:

a. Countdown Circuit

A countdown circuit is provided for the purpose of limiting the

duty cycle of the equipment while utilizing high radar repetition rates for triggering. The circuit functions at rates as high as 3000 pps.

b. Pulse Counter

The pulse counter accepts the output of the countdown circuit and, depending upon the setting of the pulse counter control, continuously counts preset groups of pulses with an accuracy of $\pm$ 12.5%. Coincident with the last pulse in each counted group, the counter produces a single pulse with such characteristics as required for the operation of the quadruple gate generator.

c. Quadruple Gate Generator

This circuit accepts the output of the pulse counter for the purpose of developing enabling gates for Modes 1, 2, 3 of SIF interrogations, and Mode 4 (Mark XII) operation. There is a single mode gate for each counter output pulse and each counter pulse simultaneously terminates the active gate and initiates the next successive gate. The delay between 50% amplitude points of the counter pulse and the resultant gate is not more than 2.5 useconds. The gates are generated in six different combinations.

d. SIF Coder

The SIF Coder accepts an adjustably delayed trigger and the Modes 1, 2 and 3 gates from the quadruple gate generator and delivers such pulses to the modulator as required to produce the pairs of RF pulses characteristic of Mode 1, 2 and 3 interrogations.

A circuit is provided which accepts the output of the counted-down radar trigger and the enabling mode gate(s) appropriate to the interrogation mode(s) selected by the interrogator switch(es), and produces a delayed pulse peculiar to the mode selected which can be mixed with the data transmission information generated in the synchronizer of the local radar. The indicators associated with the synchronizer

video channel utilize the coded I-R pulse for separation of the associated modes of IFF video.

5. Transmitter

The Transmitter of the AN/TPX-28 Interrogator is housed in a module 8" long by 4-1/2" high by 4" wide and contains the modulator, power oscillator, and driver amplifier. The entire unit is sealed to maintain atmospheric pressure during high altitude operation to prevent arc-over of the high voltage.

The modulator receives the coded signals from the Coder-Synchronizer and raises them to a suitable level for modulation of the power oscillator. The power oscillator generates the RF signal in accordance with the modulation and the driver amplifier brings this signal to a 1 to 2 kw level. Grid modulation is used on the oscillator and grid drive is used at the driver amplifier, thus making possible the use of an extremely small and compact modulator.

The high voltage power supply for the Oscillator-Driver is housed in the cover of the Oscillator-Driver module. This supply employs several features that result in appreciable savings in size and weight. It is therefore practical to house this circuit in the same module with the Oscillator-Driver circuitry proper.

6. Receiver

The receiver is housed in a module 8" long by 4-1/2" high by 3" wide with all connections located at the bottom of the module. The Receiver module is subdivided into two major subassemblies: The RF block which houses the preselector, RF amplifier, local oscillator, and the crystal mixer; and the IF assembly which consists of the IF amplifier and the video circuits. This module receives, amplifies, and detects the incoming RF signals, and presents the video signals

to the Video Separator. A removable cover is provided on the unit to allow for testing and adjustment while it is in place on the Main Chassis.

The Receiver is of the superheterodyne type; the receiver local oscillator is stable to within 0.2 mc of the selected frequency under all combinations of service conditions. Image rejection greatly exceeds 60 db. Tuning adjustments and suitable test points are accessible for service adjustment. The Receiver noise figure is better than 9 db.

Receiver gain can be controlled manually as well as automatically. This automatic control is achieved by the GTC circuit which desensitizes the Receiver immediately following transmission of an interrogation pulse train. The Receiver sensitivity is then automatically controlled so as to increase with time to a selected sensitivity level according to a preset pattern. This action affords a degree of compensation for the strong replies emanating from nearby targets. Provisions exist for switch selection of a low sensitivity level and a normal sensitivity level.

Ten independent video outputs are provided, two for each mode of interrogation and two composite video outputs. The video outputs related to specific interrogation modes are gated by the mode gate generator and provide an output only during the reply period related to that interrogation mode. The composite video output continuously presents the receiver output to a single panel jack. The level of each video output is independently adjustable when the output is properly terminated.

Provisions are present for remote control operation.

7. Video Separator

The Video Separator accepts the video from the Receiver and

the mode gates from the Coder-Synchronizer, and routes the reply signals to the appropriate channels. Line drive amplifiers on the output present a sufficiently low source impedance so that relatively long lengths of coaxial cable can be driven without deterioration of the video signals. Two independent outputs for each mode are available as well as two unsorted video outputs.

The Video Separator module is housed in a container 4-1/2" high by 3" wide by 1-3/4" long.

8. Power Sources and Power Supplies

The equipment gives specified performance from the following power sources:

AC Power (Single Phase), 115 volt, 400 cps nominal:	Less than 500 VA
DC Power, 28 volt:	None used

Overload protection for the equipment is provided. All parts and circuits of the equipment which are likely to carry an overload due to any failures or poor adjustments are proportioned to withstand such overload without permanent damage to the equipment, or are equipped with protective devices.

Automatic provisions are incorporated within the equipment to prevent the modulator from applying pulses to the transmitter until the tube cathodes have been heated. The design of this automatic warm-up provision is such as to function (re-cycle) in event of a failure of the primary AC power supply.

a. Transistor Power Supply

The Transistor Power Supply furnishes all the voltage required for the operation of the transistor circuits and also serves as the 28 V source for relays. This power supply is completely transistorized and

is characterized by highly efficient operation. It is housed in a module 4-1/2" high by 3" wide by 2-1/2" deep.

b. Filament/B+ Power Supply

The Filament/B+ Power Supply furnishes the B+ and filament power for the Receiver and the filament power and bias voltages for the Transmitter. This supply is also completely transistorized and achieves a high degree of efficiency. It is housed in a container 4-1/2" high by 3-1/2" deep by 3" wide.

9. AN/TPX-28 Interrogator Set Characteristics

Contents	Coder-Synchronizer (1 module) Transmitter (1 module) Receiver (1 module) Video Separator (1 module) Power Supply (2 modules)
Size of Interrogator	11-3/4" wide x 17-1/4" deep x 8-1/2" high (includes connectors but not case) 13-3/8" wide x 24" deep x 10-1/16" high (includes case)
Weight of Interrogator	75 pounds
Service Conditions	(per MIL-E-16400 which includes the following)
Temperature	$-54^{\circ}C$ to $+65^{\circ}C$
Altitude	in excess of 10,000 feet
Cooling	Forced Air
Input Power Requirements	115V, 400 cps, single phase, less than 500 VA; (DC power derived from this)

a. Receiver Characteristics

Receiver Frequency	1090 mc (adjustable from 1090 mc to 1110 mc)
Frequency Stability	$\pm$ 200 kc

Noise Figure	Less than 9 db
Dynamic Range	In excess of 50 db
Receiver Bandwidth	Greater than 8 to 10 mc at 3 db down; less than 18 mc at 40 db down
Receiver Sensitivity	-94 dbv to -97 dbv
Overall gain	Greater than 110 db
Intermediate Frequency	60 mc nominal
Image Rejection	In excess of 70 db
Band Rejection	70 to 75 db down for all frequencies outside the 1090-1110 mc band
Rejection at $\pm$ 10 mc from Receiver Frequency	50 db down

b. Coder-Synchronizer Characteristics

Interrogation pulse characteristics

Duration	0.45 $\pm$ 0.1 usec
Rise Time	0.1 usec or less
Decay time	0.15 usec or less

Interrogation Modes

Mode	Pulse Spacing (Usec)
1	3 $\pm$ 0.1
2	5 $\pm$ 0.1
3	8 $\pm$ 0.1
4 (Mark XII)	Classified

SECTION 13

Miscellaneous Recommendations For Improvement of the AN/TSQ-47

1. General

Although not considered important enough to merit elaborate discussion, the following items are submitted as suggestions for additional improvement of the AN/TSQ-47.

2. Requirement For Extension Cord and Trouble Lamp in All Shelters

Each shelter should be provided with a 25 ft. extension cord with connector receptacles and a trouble lamp. This would aid in troubleshooting where illumination and/or power receptacles are not adequate.

3. AN/TPS-35; Requirement For Shelf Above Microwave RF Power Supply

In the AN/TPS-35 search radar, the microwave RF power supply is located at the bottom of one of the microwave racks. Since the rack is not completely filled with equipment, there is a large vacant space above the RF power supply. It has been noted that personnel in the shelter tend to use the power supply as a shelf for storing manuals, etc. The manuals can block the air flow through the power supply and possibly cause failure. In addition, coffee or other liquids could be accidently poured into the power supply. This difficulty could be eliminated if a metal shelf were placed about 2 inches above the power supply. The shelf should have sufficient area to adequately protect the power supply. Since the microwave racks are standard size, such shelves can probably be directly purchased from commerical sources.

4. <u>AN/TPS-35; Blockage of Air Flow From Microwave Receiver and Transmitters by Blackout Curtain</u>

In the AN/TPS-35, when the blackout curtain at the entrance is tied back, there appears to be a tendency to block the air outlets of the microwave receiver and transmitters. It is recommended that this condition be investigated more thoroughly, and corrections be made if required.

5. <u>AN/TSW-5; Requirement For Intercommunications Between Control Center Shelter and A/G/A Shelter</u>

At present, the only means for communication between the control center and the A/G/A is via RACEP. Since the physical separation of these shelters is normally not more than 25 ft., this seems to be an inefficient use of RACEP. Also, distortion can result when the RACEP equipments are separated by less than 500 ft.

Intercommunications between the control center and A/G/A shelter is required in order to enable the technician in the A/G/A to rapidly set the communications equipment to the conditions desired by the operators in the control center. It is therefore recommended that a small, transistorized, intercommunications facility be installed between the control center and the A/G/A. The unit should operate from the 28 VDC shelter supply. The installation should conform to good human engineering practices relative to the communications requirements between the shelters.

6. <u>AN/TSW-5; Requirement For Microphone Extension Cord on Order Wire Unit</u>

The order wire unit is equipped with a hand-held microphone with a coiled retractable cord. This cord is satisfactory for microphones at all microwave terminals except at the AN/TSW-5. For added

convenience, it is recommended that a coiled retractable extension cord be provided for the order wire at the AN/TSW-5. This extension cord should have connectors to allow it to be connected between the present microphone cord and the order wire unit.

7. Diesel Generators For Extended Deployment Periods

The present AN/TSQ-47 was designed for deployment periods of not more than 30 days. Extended deployment periods exceeding 30 days could cause serious logistics problems in regard to the gas turbine generators which require overhaul after 1500 hours of operation. The generator overhaul cannot be accomplished in the field.

As a result of this situation, it is recommended that, for extended deployment periods, diesel generators be utilized. The diesel generators could be kept at a central location until required. Only one diesel generator per subsystem (shelter) would be necessary provided the capacity was adequate. During down-time of the diesel generator for scheduled maintenance or in an emergency, power could be provided temporarily by the regular gas turbine generators. This would greatly reduce the operating time accumulated on the turbine generators. Utilization of diesel generators would also allow some of the spare turbine generators to be returned to the depot for overhaul when this requirement arose.

Since the diesel generators would be too heavy for manual handling, it is recommended that each generator be permanently mounted on a pallet. The recommended pallet is Skid, Platform, MX-4521/TSQ-47, or equivalent, which is compatible with the 463-L cargo aircraft rail system and the transporters to be employed with the AN/TSQ-47. This would enable the generator to be loaded on and unloaded from the aircraft and to be transported to the site with a

minimum of equipment and handling.

For extended deployment in areas where commercial power is available, it may be desirable to consider the utilization of motor generators (to convert from commercial power to 400 cps power) in place of the diesel generators.

8. Accessories Required to Enable Turbine Generators to Operate Directly From 55 Gallon Fuel Drum

The turbine generator is equipped with a ten gallon fuel tank and also has a fuel pump which will automatically fill the 10 gallon tank from an auxiliary fuel tank. During deployment in the field, in most instances, a 55 gallon drum will be used as the auxiliary fuel tank. It is recommended that each generator be equipped with the following additional accessories to facilitate operation with a 55 gallon drum as an auxiliary fuel tank.

a. Siphon tube and fuel level warning device

A 55 gallon drum has a large threaded plug and a small threaded plug on the top end. It is recommended that a siphon tube with a low-fuel warning device be designed to fit into the large threaded opening.

The top end of the siphon tube should be equipped with a removable filter and a quick-disconnect hose connector. On the opposite end, the tube should probably be equipped with a removable strainer and should extend to within approximately one or two inches from the bottom of the fuel drum. The space at the bottom is left to allow for water or residue which may be in the drum.

A low-level fuel warning device should be placed on the siphon tube at a distance far enough from the bottom of the drum to provide a warning 30 minutes before the fuel in the drum is exhausted. The

device should provide contact closure capable of operating a remote low-fuel warning light and/or buzzer in the associated shelter. The contacts should be hermetically sealed to prevent any possibility of fire or explosion. If wiring is required inside the drum, it should be sealed in metal conduit. A binding post for ground connection should be provided near the top end of the siphon tube. A quick-disconnect, waterproof, electrical connector should be provided outside the drum to enable connection of the cable from the signaling equipment within the shelter. The low-fuel-level signaling equipment within the shelter should provide the necessary current or voltage to enable the sensing of the contact closure resulting from a low fuel level in the drum. The signaling equipment should be sensitive enough to enable operation with currents or voltages low enough to prevent any possibility of fire or explosion from electrical discharge. Transistor amplification will probably be necessary.

b. Vent Tube for Fuel Drum

The small threaded hole on the fuel drum should be provided with a vent tube to prevent interruption of fuel flow as a result of a vacuum being created within the drum. This device could be in the form of a threaded plug with a short tube welded at the center. The tube would allow air to enter the drum, and should be curved downward at the top to prevent rain from entering. The plug should make a water tight seal with the threaded hole in the drum.

c. Fuel Hose for Connecting Fuel Drum to Generator.

An adequate length of fuel hose should be provided to enable connection of the fuel drum to the generator. The hose should be equipped with appropriate quick-disconnect connectors to enable attachment to the generator at one end and the siphon tube at the other.

9. Lean-to For All Shelters

The AN/TSC-23 is equipped with a lean-to which attaches to one end of the shelter and provides additional storage space with protection from the weather. The lean-to is made of canvas with metal supports and can be folded into a small package for transport within the shelter. It is recommended that all other shelters within the AN/TSQ-47 be equipped with a lean-to similar to that provided with the AN/TSC-23.

10. Extended Range Presentation of the IFF/SIF Mode On PPI's in the AN/TSW-5

a. General

In the present configuration of the AN/TSW-5 RAPCON, IFF/SIF information is provided to all the Plan Position Indicators, but the maximum range presentation of the units is only 80 n. miles. This condition is due to the AN/TPS-35 Timing System, which determines the 80 n. mile terminal area. However, under certain conditions it may be necessary to locate or identify an aircraft at some distance greater than 80 n. miles. To provide the extended IFF/SIF range presentation, it will be necessary to make minor modifications to the AN/TSW-5 sub-system.

b. Trigger Count-down

Since the trigger rate is 800 pps, it will be necessary to supply a 2:1 count-down circuit to provide a 400 prf. This would involve a solid state board which would operate from the existing 28 vdc power source.

c. Video Blanking

The next modification would consist of the design of a video blanking circuit to blank the normal radar video after the 80 n. mile

period and up to the 200 mile period.

Four of these circuits would have to provided, one for each PPI unit.

d. Function Switch

The function switch on each PPI unit would contain a 200 mile beacon position, with beacon information only available, or a combination of normal video from zero miles to 80 n. miles, and beacon video from zero miles out to 200 n. miles. Each switch position would provide a gating pulse to turn on the count-down circuit, and pass the IFF/SIF video, and the trigger to the PPI.

e. Interrogator at AN/TPS-35

The AN/TPS-35 interrogator unit would be set in the long gate mode of operation to permit the RT-211 Receiver to remain open during the full cycle.

11. <u>Improvement in Shelters Recommended For Operation With 463L Loading System</u>

The shelters in the AN/TSQ-47 are provided with rails so that they may be loaded aboard aircraft equipped in conformance with the 463L aircraft loading system. The present rails must be bolted to the shelters prior to loading aboard the aircraft and must be removed after the shelter is unloaded from the aircraft. In addition to being time consuming, this method of operation causes storage problems and could result in loss of hardware.

It is recommended that a study be made to determine the feasibility of designing shelters with built-in rails. Under the 463L concept, aircraft are equipped for rails with either 88 inches or 108 inches sepration. The shelter rails could be designed to extend from the shelter and mate with the rail system in the aircraft; when

not in use, the shelter rails would retract flush with the shelter walls. It may be desirable, where feasible, to design the shelter rail mechanism to extend to either 88 inches or 108 inches.

The rail positioning could be controlled from one end of the shelter by means of a hand crank. Operation of the crank would cause the rails to be extended from the shelter by means of a rack and pinion, jack-screw, or other appropriate mechanism. Locking pins would hold the rails in the desired position after extension.

By a sophisticated design approach, it should be possible to incorporate the rail assembly into the shelter without adding a great deal of weight. The design could be such that the rails and supports would add to the strength of the shelter when retracted. It may be possible to have the rails, when retracted, act as supports for the skids on the shelter.

12. Remote Thermostat For Air Conditioners

The present air conditioner has a local thermostat for controlling the temperature of the air going to the shelter. In addition to being inconvenient, this method of control frequently requires several adjustments before a comfortable temperature can be established in the shelter. To overcome this situation, it is recommended that the air conditioner be designed to operate from either its own thermostat or a remote thermostat in the shelter. A connector should be provided on the air conditioner for connecting the cable from the remote thermostat. In addition, a REMOTE-LOCAL switch should be provided for selecting the remote or local thermostat.

The shelter should be equipped with a thermostat capable of maintaining the temperature by remotely controlling the air conditioner. The shelter thermostat should contain a scale marked in degrees

Fahrenheit and a method for setting the desired temperature. In addition, the shelter thermostat should be equipped with a thermometer for indicating the ambient temperature.

13. Additional Filtering of Shelter Air Return

Filtering of the air for the shelter is accomplished at the air conditioner by means of a resuable filter on the air-return side of the air conditioner. It is recommended that an additional air filter be installed within the shelter at the entrance to the air return duct. This is considered necessary in order to prevent clogging of the R.F. shielded air vent at the entrace to the air return duct. This vent is of honeycomb construction and would be difficult to clean, even if it could be removed.

SECTION 14

CONCLUSIONS AND RECOMMENDATIONS

This report lists many recommendations for improvement of the AN/TSQ-47 and associated equipment. The range of recommendations extends from minor improvements to major redesign (in the case of the AN/TVN-1 lighting system). The recommended improvements include those which contribute to improved operational efficiency, greater reliability, savings in cost, savings in weight, and combinations thereof.

Careful consideration should be given to the implementation of these and future recommendations that will undoubtedly be received as field testing of the AN/TSQ-47 continues.

In order to accomplish this task, the Air Force should establish a special group to review and evaluate recommended improvements, to implement improvements which are acceptable, to solicit additional improvement recommendations, and to recommend improvements for problems which arise and for which no outside improvement recommendations are received. In addition, it is recommended that while two of the AN/TSQ-47's are being field tested, the remaining system be held for design, installation, and modification according to present and future recommendations for improvement, and for test and evaluation of these improvements.

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13. ABSTRACT

This report concerns the AN/TSQ-47 System Integration in accordance with Contract AF19(6Q4)8020, item 8. This Report provides specific recommendations concerning improvements to ehe AN/TSQ-47 System, in many arear, as well as to the support subsystems of the EMS concept.

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